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Development of a Premier Northern River Fishery: Mesilinka River, the First Year of Fertilization (1994)

A. J. Paul, C. W. Koning, K. I. Ashley, P. A. Slaney, P. W. Davidson and R. W. Land

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ABSTRACT

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The addition of inorganic nutrients to increase fish production in the Mesilinka River, a northern interior river of British Columbia, is currently being investigated. Increased production of native fish stocks is desired to both offset negative impacts following the establishment of the Williston Reservoir and to meet increased angling demands for stream fisheries. In this report we present the results from the first year of fertilization (1994) to the mainstem Mesilinka River which has a mean annual discharge of 181, 108 and 49 $m^3 s^{-1}$ in June, July and August, respectively. Three reaches on the Mesilinka River (an upstream control reach, Blackpine, and two downstream treatment reaches, T1 and T2) and an additional external reference system (the Nation River) were established to test the effects of added nutrients to stream production. Inorganic fertilizer was added above T1 as ammonium polyphosphate, 10-34-0 (indicates percent weight of N - P_2O_5 - K_2O), and urea-ammonium nitrate, 28-0-0. Another fertilizer station downstream of T1, but above T2, added only ammonium polyphosphate. Due to clogging of the fertilizer drip valves, actual loading rates of nitrogen (N) and phosphorus (P) were lower than target loadings of 15 µg N L^{-1} and 5 µg P L^{-1}. Mean summer loadings of N and P at the upper fertilizer station were 9.0 µg N L^{-1} and 4.5 µg P L^{-1}, and at the lower station (10-34-0 only) were 2.4 µg N L^{-1} and 3.6 µg P L^{-1}. Rapid uptake of added P was evident by the low concentrations (below detection limits) of soluble reactive phosphorus (SRP) several kilometres downstream from the fertilizer stations. However, during brief periods when SRP increased above detectable limits in the Mesilinka River it was greatest in the two treatment reaches. Fertilizer additions likely drove algal production from P limitation to N limitation, especially in T2, as indicated by the rapid decline in dissolved inorganic N following the start of fertilization. Despite lower than targeted fertilizer loading rates and possible N limitation, periphyton responded strongly to the nutrient additions. Peak periphyton biomass determined from artificial substrates and measured as chlorophyll a was 10 and 2 fold higher in T1 and T2, respectively, than the control reach or the Nation River. Hypotheses accounting for the different accrual of periphyton between treatment reaches are presented. Benthic invertebrate biomass, determined from artificial substrate baskets, increased 2 fold in T1 and T2 as compared to Blackpine. However, the increase in invertebrate biomass was not statistically significant due to the high within-reach variability in these estimates. Adult fish densities in T1 and T2 were higher for combined rainbow trout, bull trout and Arctic grayling in 1994 than previous years; however, this can not be attributed to fertilization as densities were also higher for Blackpine in 1994. Mean fork lengths and weights for adult rainbow trout and grayling did not differ among treatment and control reaches. Similar to measures of invertebrate biomass, within-reach variability in mean lengths and weights may reduce the ability to detect significant differences unless sample sizes are increased and effects from nutrients are large. The relative importance of rearing habitats for juvenile rainbow trout, bull trout and grayling are uncertain and require further study.

ACKNOWLEDGEMENTS

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Taxonomic identification and enumeration of benthic invertebrates was prepared by Fraser Environmental Services, #16 - 9324 128th Street, Surrey, B.C., V3V 6A4.

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INTRODUCTION

Production of consumers, including benthic invertebrates and fish, in streams is driven by energy inputs from within and outside the system. Energy inputs from outside the stream are derived from the transport of organic matter (e.g. leaf litter) from the watershed (Hynes 1975). Energy pathways developed from within a stream stem from the primary production of periphytic (attached) algae which is dependant on nutrient and light conditions (Minshall 1978; Peterson et al. 1985; Perrin et al. 1987). Increasing the supply rate of inorganic nutrients (nitrogen or phosphorus) within a stream can change a system from relying on energy attained by the transport of organic matter from its watershed to within stream production of periphytic algae (Peterson et al. 1985).

Increased growth of periphytic algae can result in increased production of fish (Johnston et al. 1990; Deegan and Peterson 1992; Slaney and Ward 1993). Increasing algal production can lead to higher biomass of aquatic insects (Johnston et al. 1990; Slaney and Ward 1993), likely due to both higher quality and more abundant food resource for the insects (Cummins and Clug 1979; Gregory 1983). Subsequently, higher insect biomass has been shown to increase salmonid food resources and decrease their territory size, thereby increasing the carrying capacity of a stream for salmonids (Warren et al. 1964; Chapman 1966; Slaney and Northcote 1974; Dill et al. 1981; Wilzbach 1985).

The addition of inorganic nutrients in lakes and streams may be an effective technique to mitigate the negative impacts of either lake impoundment or logging on native fish populations (Milbrink and Holmgren 1981; Slaney et al. 1993). These negative impacts include the loss in productivity of fish in impounded lakes (Milbrink and Holmgren 1981) and a decrease in overwinter survival of steelhead trout (Oncorhynchus mykiss) in logged watersheds (Slaney et al. 1993). Nutrient input into an impounded lake in Scandinavia was shown to rapidly increase productivity at all food web levels (Milbrink and Holmgren 1981). Furthermore, nutrient inputs into coastal streams can increase the mean weight of juvenile steelhead trout (Johnston et al. 1990; Slaney and Ward 1993) and thereby increase their overwinter survival (Hume and Parkinson 1988).

The use of nutrients to maintain or enhance fish stocks may be a more effective and ecologically sound technique than the introduction of non-native species. The introduction of non-native fishes in freshwaters has likely resulted in a greater loss in biodiversity than any other anthropogenic stress (Schindler 1990); while, the introduction of non-native invertebrate species intended as a food resource (e.g. mysids) has had unpredictable and disastrous ecosystem effects (Ashley and Thompson 1993). Introduced invertebrates have sometimes achieved results exactly opposite of what was intended (Ashley and Thompson 1993) or have provided an extra food-web link to increase toxin concentrations in top predators (Cabana and Rasmussen 1994). While species introductions proceed largely unregulated after stocking, nutrient additions can be carefully regulated such that species biomass changes but not species richness (Milbrink and

Holmgren 1981; Peterson et al. 1993a), thus maintaining biodiversity (Quamme 1994). Furthermore, the effects of regulated nutrient additions on a stream can be reversible (Slaney and Ward 1993).

The purpose of the Mesilinka River Fertilization Experiment is to determine whether fertilization is a suitable technique to increase production of native fish species, especially Arctic grayling (Thymallus arcticus), bull trout (Salvelinus confluentus) and rainbow trout (O. mykiss), within the Williston Reservoir watershed. The reasons for enhancing fish production are twofold. First, a large portion of the riverine habitat of the Rocky Mountain Trench was lost with the creation of the Williston Reservoir behind the W.A.C. Bennet dam (Blackman 1992). Critical over-wintering refuges or foraging zones were probably lost, especially to highly migratory species such as Arctic grayling or bull trout in this large watershed. Lacustrine fish species currently dominate catches within the reservoir while riverine species, such as grayling and mountain whitefish, have declined significantly following impoundment (Blackman 1992). Therefore, increased grayling production through river fertilization may partially offset the loss in grayling stocks from impoundment. Unfortunately, no historical records of grayling stocks prior to impoundment are available for the 3 major rivers that were flooded (Parsnip, Finlay and Peace) and their numerous tributaries. Secondly, user surveys within the Williston watershed indicate that angling preference favours rivers over small lakes and especially over the reservoir (B.C. Hydro 1990). Decreased riverine habitats from impoundment will thus be subject to increased angling pressure. Furthermore, stream fisheries are sensitive to overharvest and decreased quality following increased angling pressure (Slaney 1986). Therefore, river fertilization may develop destination fisheries that can support increased angling pressure while alleviating pressure on other unfertilized systems within the watershed.

The Mesilinka River (Fig. 1) was chosen as the primary site for fertilization for several reasons as outlined in Koning et al. (1995). These include suitable water temperatures, amount and type of nutrient deficiency, suitable rearing and overwintering habitat, adequate juvenile recruitment, and accessibility for anglers (Koning et al. 1995). Pre-fertilization data on discharge, temperature, nutrients, periphyton, invertebrates, and fish were collected from the Mesilinka River between 1991-1993 (Langston 1992; Koning et al. 1995). As well, the Nation River (Fig. 1) was similarly sampled but to a lesser extent between 1992-1993 to serve as an external reference system (Koning et al. 1995).

The objective of this report is to describe the results from 1994 for both the Mesilinka and Nation rivers. This marked the first year of fertilization to the mainstem Mesilinka River as fertilization began in late June.

Figure 1 - The Williston Reservoir watershed. Map from Langston (1993).

STUDY AREAS

Mesilinka River

The Mesilinka River is located in north central British Columbia (Fig. 1) originating within the Omineca Mountains and running for approximately 120 km before emptying into the Williston Reservoir. The Mesilinka River flows through one lake, Aiken Lake, approximately 20 km downstream from the headwaters of the Mesilinka. Physical and biological conditions of the Mesilinka River and its watershed are given in Koning et al. (1995). Briefly, flows on the Mesilinka River peak in spring and early summer with the maximum monthly mean occurring in June (175 $m^3 s^{-1}$). Mean summer temperatures for the river are 10-11 °C and nutrient levels, especially dissolved phosphorus (P), are extremely low and often below detectable levels (ie., 1 $\mu g L^{-1}$; Koning et al. 1995). Primary productivity of the system is low, as confirmed by the low accrual of periphyton on artificial substrata and visual inspection of boulders, cobbles and pebbles for periphytic algae (Koning et al. 1995).

Fish communities consist of rainbow trout, Arctic grayling, bull trout (Salvelinus confluentus), mountain whitefish (Prosopium williamsoni), burbot (Lota lota), suckers (Catastomus spp.), sculpins (Cottus spp.), longnose dace (Rhinichthys cataractae), northern squawfish (Ptychocheilus oregonensis) and likely other cyprinids.

The mid to lower portion of the Mesilinka River was used to test the effects of fertilization (Fig. 2). This section was chosen because: a) temperatures are warmer than upper reaches, b) nitrogen (N) may not be as limiting in the lower portions due to ground water input of N and c) the lower portion has several road access points making it more suitable for a destination fishery (Koning et al. 1995). Three study reaches of the mid to lower river were established in 1992 (Koning et al. 1995) and maintained in subsequent years to facilitate a before and after unreplicated experiment (Stewart-Oaten et al. 1986). A control reach (Blackpine) was located approximately 30 km and 60 km upstream of the upper treatment reach (T1) and lower treatment reach (T2), respectively (Fig. 2).

Several tributaries flow into the mid to lower portion of the Mesilinka River (Fig. 2). A number of these tributaries provide rearing habitat for juvenile rainbow trout, bull trout and mountain whitefish (Koning et al. 1995). Five tributaries (Fatfish, Carina, Gopherhole, Control and Culvert creeks; Fig. 2) in the vicinity of the two treatment reaches were studied in detail (1992-1993) to assess their rearing potential for juvenile fish (Koning et al. 1995). Furthermore, two creeks (Culvert and Gopherhole) were fertilized in 1993 to assess whether fertilization could enhance juvenile growth and recruitment in these tributaries (Koning et al. 1995). The five tributaries were again studied in 1994; however, Culvert and Gopherhole creeks were not fertilized in 1994.

Nation River

The Nation River, approximately 100 km south of the Mesilinka River, also flows into the Williston Reservoir. The river is headed by a chain of 5 large lakes (the Nation lakes) that are situated at the southern end of the Omineca mountains (Fig. 1). Mean summer water temperatures (14-15°C) and flow rates are higher than the Mesilinka River (Koning et al. 1995). The Nation River tends to be limited in N as well as P unlike the Mesilinka River which has higher concentrations of dissolved N (Koning et al. 1995). The Nation River was not chosen as a primary fertilization target because the higher flow rates coupled with N-limitation would necessitate larger (more costly) amounts of fertilizer than required for the Mesilinka River. If

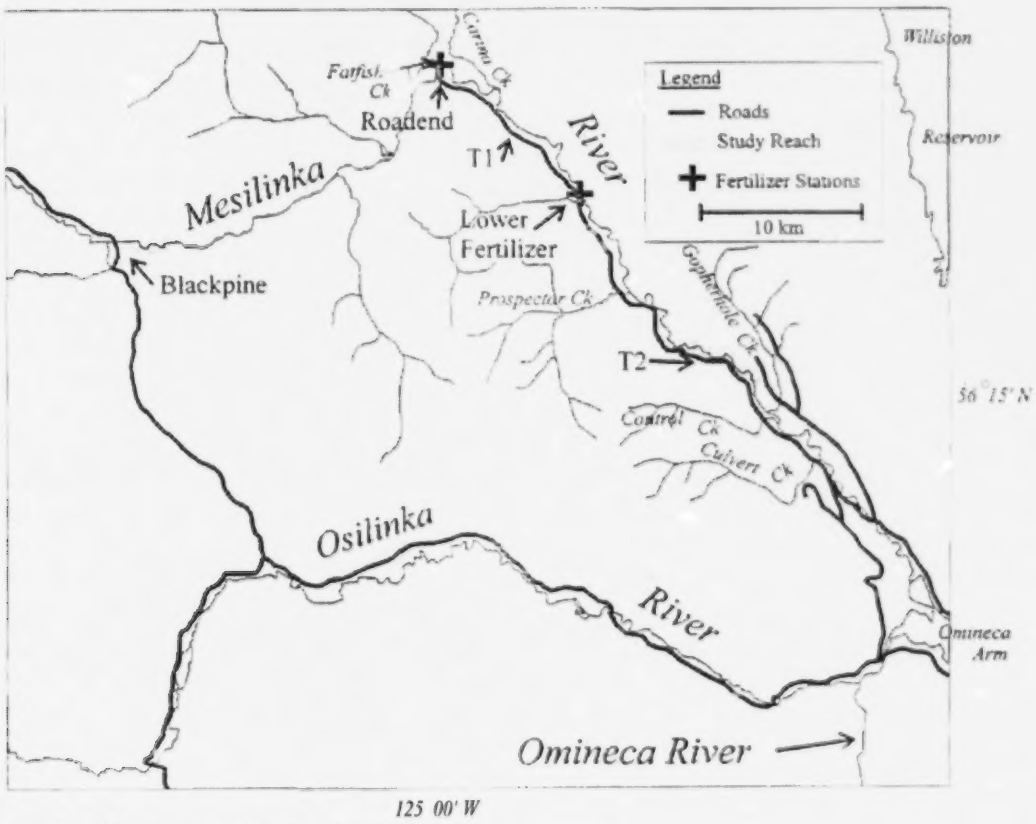

Figure 2 - Mid to lower portion of the Mesilinka River.

fertilization of the Mesilinka River produces the desired results in a cost-effective manner the Nation would then be considered as the next candidate river for fertilization.

METHODS

Methods utilized in 1994 were consistent with those followed in 1992 and 1993 for the Mesilinka River (Koning et al. 1995). Furthermore, the methods followed for the Mesilinka Fertilization Project are similar to a number of fertilization projects headed by the Fisheries Research and Development section within the Ministry of Environment, Lands and Parks. These methods have been described elsewhere (Slaney et al. 1993; Toth et al. 1993; Koning et al. 1995). Methods for the Mesilinka River in 1994 are outlined below.

Weather

A record of local weather conditions was obtained from Environment Canada. The closest Environment Canada weather monitoring station to the Mesilinka River is located at Germansen Landing (Fig. 1). Records obtained from Environment Canada (May-October) include daily maximum, minimum and mean temperatures; amount and form of precipitation; and snowpack depth. Mean air temperatures for Germansen Landing were compared to mean air temperatures from a max/min thermometer located on the Mesilinka River. In both cases, means were taken as the average between maximum and minimum daily temperatures.

Hydrology

Daily discharge from the Mesilinka and Nation rivers was obtained from the Water Survey of Canada (WSC). WSC monitor discharge from 1 site on the Mesilinka (approx. 20 km from its mouth) and 2 sites on the Nation. Because daily discharge rates from the Mesilinka River were needed in 1994 to set fertilizer drip rates to achieve target concentrations, a stage-discharge relationship was established using 1993 data. Readings from a staff gauge located at Blackpine were regressed against WSC discharge rates using an exponential equation (base 10). The staff gauge at Blackpine was used as it was the only one available from 1993. We tested whether predictions from this stage-discharge relationship were statistically different from values obtained by WSC in 1994 using a paired t-test. Statistical significance was set at $P < 0.05$. To facilitate discharge estimates in 1995, two new staff gauges were installed at Roadend and the lower fertilizer site (Fig. 2). As well, a second more permanent staff gauge was installed at Blackpine on the concrete bridge pilings. These staff gauges will be calibrated to 1994 discharge readings from WSC.

Discharge for the 5 tributaries was calculated using stage-discharge relationships from 1993. Water level readings were taken from permanent staff gauges located in each of the tributaries weekly to biweekly between 29 June and 31 August 1994. Discharge was estimated using the staff-discharge relationships in Koning et al. (1995). We tested whether estimations from the 1993 equations differed from actual discharges measured in 1994 using Wilcoxon signed rank tests. Discharge was calculated by summing flows from cells at 0.5 m intervals across the creek. Flows from the individual cells were calculated by multiplying velocity by cell

area (0.5 m X water depth). Velocities were measured at 60% total depth from the surface using a Marsh-McBimey current meter. Statistical significance was set at $P < 0.05$.

Water Temperatures

The growth rates of periphyton, invertebrates and fish are dependant on ambient thermal regimes. Water temperatures were recorded at 2 sites in the Mesilinka River (Blackpine and the lower river; Fig. 3) and 1 site in the Nation River (Fig. 1) using remote thermographs (Onset Instruments, Pocasset, MA.) that digitally record temperature every 2 hours. Water temperatures of the five tributaries at sites near their mouths (Fig. 3) were also recorded using these thermographs. Thermographs were installed by mid June and removed at the beginning of September. Temperatures from the thermographs were corrected to biweekly temperatures recorded from calibration thermometers. Precision of the calibration thermometers were 0.1 °C prior to 11 July 1994 and 0.5 °C afterwards (the change in precision resulting from different thermometers). Temperatures from the thermographs are summarized in Langston (1994).

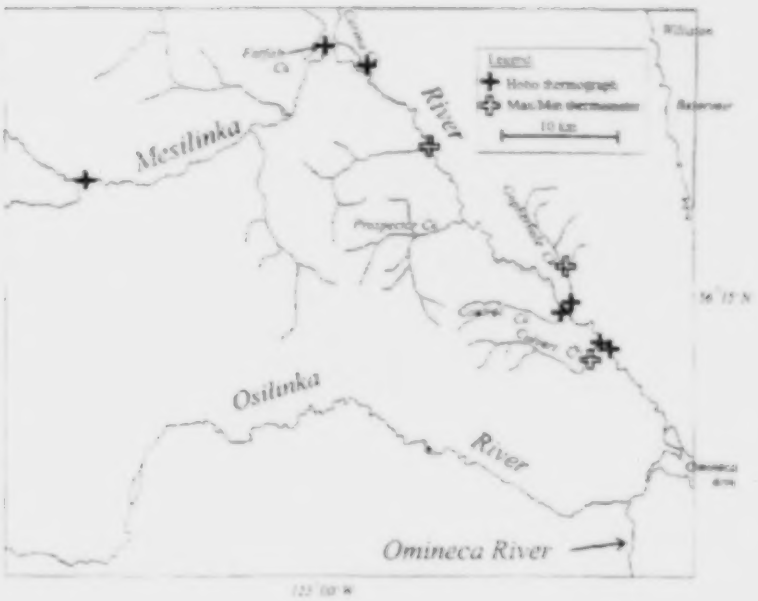

Figure 3 - Location of thermographs and max/min thermometers in the Mesilinka River and tributaries.

Max-min thermometers were installed at 3 additional localities and monitored weekly to biweekly (Fig. 3). Two sites were in upper Culvert and Gopherhole creeks where fertilizer was added in 1993 (see Koning et al. 1995). Thermometers at these two sites were installed 26 June and removed 31 August. The remaining site was at the lower fertilizer station on the Mesilinka

River (Fig. 3) approximately midway between the two mainstem thermograph stations (installed 27 June and removed 29 August). Maximum and minimum temperatures were averaged to calculate the daily mean temperature. Max-min thermometers were calibrated as described above for the thermographs.

Mesilinka Mainstem Fertilization

Fertilization of the two treatment reaches, T1 and T2 (Fig. 2), was initiated on 28 June 1994. Two fertilizer stations were established on the Mesilinka River, an upper one at Roadend and a lower station approximately 20 km downstream (Fig. 2). Separate N and P fertilizer solutions were added at the upper station as N was likely to be co-limiting with P (Koning et al. 1995). N was added in solution as urea-ammonium nitrate, 28-0-0 (values indicate percent weight of solution containing N - P_2O_5 - K_2O, respectively) and P was added in solution as ammonium polyphosphate, 10-34-0 (14.9 % P by weight), also an additional source of N (10 % by weight). Instream target concentrations of N and P were 15 µg L^{-1} and 5 µg L^{-1}, respectively. Only an ammonium polyphosphate (10-34-0) solution was added at the lower fertilization station due to increasing background concentrations of dissolved inorganic nitrogen in the lower river (Koning et al. 1995). Instream target concentrations of P at the lower station were 5 µg L^{-1}.

Fertilizer additions were set by metering drip rates to preset amounts that would achieve target concentrations at a given river discharge. Drip rates were calculated from the mean of 3 repeated volumetric measurements of fertilizer taken over 2 minutes. River discharge was estimated from the stage-discharge relationship for Blackpine staff gauge readings and WSC discharge readings described previously in the hydrology section. Arrival drip rates, measured before adjusting rates, and departure rates, measured after resetting rates, were calculated every 3-4 days.

Estimated fertilizer loadings of N and P to the Mesilinka River were calculated using measured arrival and departure drip rates and actual WSC daily discharge readings for 1994. The assumption was made that discharge at the lower fertilizer station and upper fertilizer station (Roadend) were equal to the discharge at WSC station approximately 30 km downstream from Roadend. Drip rates were interpolated based on the assumption that rates changed linearly at departure on day D and arrival on day D + x (where x is the number of days between readings). Estimated daily loading rates and mean summer loadings were calculated up until the end of August. Drip rates continued through September until most of the tanks were empty.

Water Chemistry

Dissolved nutrients were monitored to assess: a) mainstem and tributary nutrient limitation on stream production, b) nutrient loading from the tributaries to the mainstem, and

c) the downstream fate of added nutrients from fertilization. Water chemistry samples were collected and processed as described by Perrin et al. (1987). All analyses were carried out by Zenon Environmental Laboratories of Burnaby following standard methods outlined in APHA (1985). Samples were collected from each of the reaches of the Mesilinka (mid-reach), the Nation and the five tributaries biweekly from 21 June to 5 September (Fig. 4). An upper and lower site on Gopherhole and Culvert creeks were sampled, the upper sites were located above 1993 fertilizer inputs (Fig. 4). The nutrient parameters monitored were NO_3+NO_2-N, NH_4-N, total dissolved N, soluble reactive phosphorus (as ortho-P) and total dissolved phosphorus. Total organic nitrogen, total nitrogen and total phosphorus were also measured. Metal concentrations were monitored as various metals are required for periphyton growth and could be co-limiting along with the macronutrients P and N. Water samples were kept cool with ice and shipped within two days to Zenon labs.

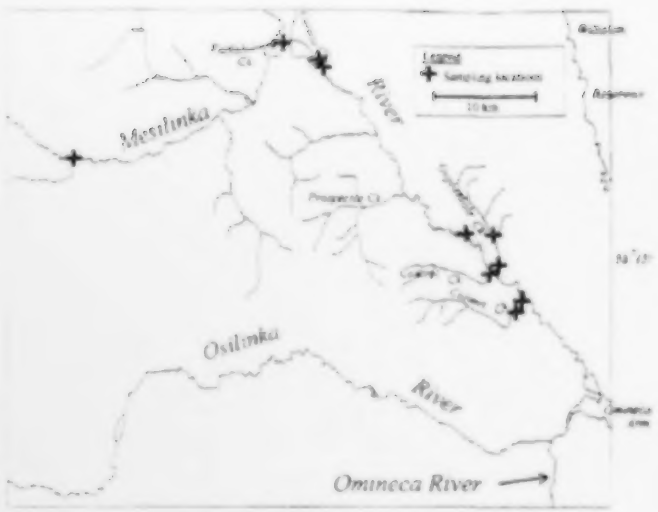

Figure 4 - Sampling locations for water chemistry from the Mesilinka River and tributaries.

Non-filterable residue, filterable residue (total dissolved solids) and turbidity were collected weekly from the Mesilinka and biweekly from the Nation from early June to the end of July. These parameters provide indices of nutrient levels (filterable residue) and light transparency (turbidity, non-filterable residue) which can affect periphyton growth or fish movement. Weekly samples were frozen until they were shipped to Zenon Laboratories for analysis.

Periphyton Accrual

Areal chlorophyll a, as measured from artificial substrates, provides a good index of the effects of nutrient addition on periphyton growth and biomass (Perrin et al. 1987). We measured chlorophyll a accrual and peak biomass on artificial substrate using methods described by Perrin et al. (1987) and Bothwell (1988). The artificial substrate consisted of styrofoam (0.40 m X 0.20 m X 0.006 m) attached to a plexiglass plate with stainless steel wire and bolted to a concrete block. Periphyton blocks were placed in moderate riffles at a depths of about 0.4 m. Blocks

were moved as water levels varied to ensure that blocks were not washed away at high flows or left dry at low flows.

Replicate periphyton blocks (2 blocks) were installed at 4 locations on the mainstem Mesilinka (Blackpine, Roadend, upper T1, and lower T2; Fig. 5) and one site on the Nation by mid-July and removed in early September. Unreplicated periphyton blocks were installed in the 5 tributaries (2 sites in Gopherhole and Culvert creeks) by late June and removed at the end of August (Fig. 5). However, heavy rains and high flows in early July washed all tributary blocks away except the two installed in Gopherhole Creek and one in Fatfish Creek. All dislodged blocks were replaced by mid-July (except the upper Culvert Creek site).

Figure 5 - Location of periphyton blocks on the Mesilinka River and its tributaries.

Duplicate chlorophyll a samples were collected biweekly from each block. A 7 dram vial was used to extract a circular sample of styrofoam with attached algae. Samples (2 vials per block) were carefully labelled, wrapped in aluminum foil and frozen until analysis. Chlorophyll a concentrations (mg m^{-2}) from the styrofoam samples were measured at Zenon Laboratories using acetone extraction and spectrophotometry (Strickland and Parson 1972). The minimum detectable limit for chlorophyll a was 0.3 mg m^{-2}.

Benthic Insect Biomass

The response of aquatic invertebrates to fertilization was assessed by measuring colonization of invertebrates on artificial substrates (Slaney and Ward 1993). The artificial substrate consisted of a cylindrical plastic basket (0.22 m in diameter and 0.13 m deep) filled with clean gravel (0.03 m - 0.06 m) as substrate. Two sets of 5 baskets were placed in riffle areas within each of the study reaches on the Mesilinka River in mid-July (Fig. 6). One set of 6 baskets was installed in a riffle on the Nation River, also in mid-July. Baskets were surrounded with cobbles to prevent dislodgement and some baskets were moved deeper as water levels receded. However, rapidly dropping water levels in late August left 1 set of 5 baskets on T1 dry.

All baskets were removed after 6 weeks and colonized invertebrates collected. At removal a Surber sampler (200 µm mesh) was placed directly downstream of the basket and the contents of the basket washed into the Surber sampler. Depths and water velocities (Marsh McBirney current meter) were recorded for each basket on its removal. Contents of the baskets were labelled and preserved in jars with enough formalin to bring its final concentration to 10%.

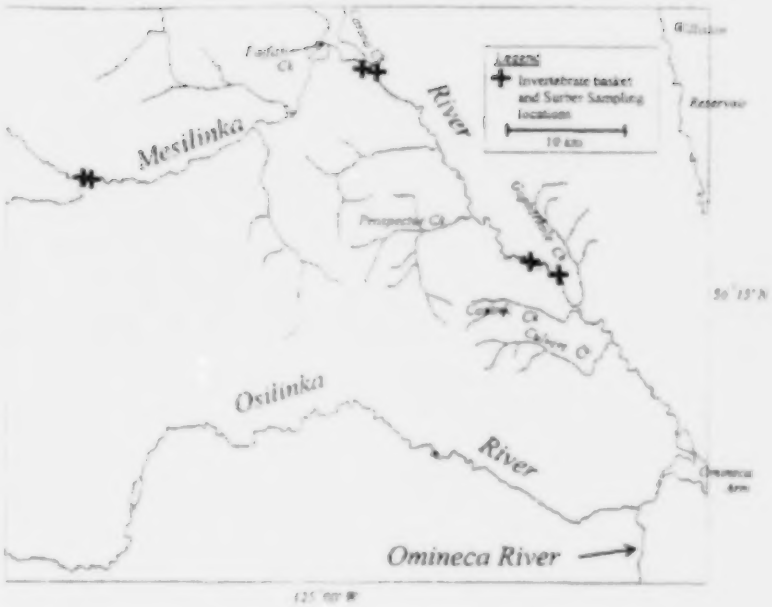

Figure 6 - Location of invertebrate baskets and Surber samples on the Mesilinka River.

Benthos samples were taken to facilitate the comparison of benthic invertebrate composition and biomass between artificial baskets and natural substrates. A series of 5 benthos samples were collected at each of the riffles where invertebrate baskets had been installed on the Mesilinka River (Fig. 6). Although the benthic sample size is limited, it was assumed it would indicate whether benthic samples were similar to the basket sampler. Benthos samples were collected using a Surber sampler of 0.09 m^2 (0.30 m X 0.30 m; 200 µm mesh) and the substratum was sampled to a depth of 0.10 m. Surber samples were collected within a week of the removal of the invertebrate baskets (late August or early September). Depths and water velocities (Marsh McBirney current meter) were recorded for each sample taken. Sampler contents were labelled and preserved in 10 % formalin. The last 10 samples collected were preserved in 60% ethanol due to a shortage of formalin. Samples preserved in ethanol were drained, washed with water and then preserved in 10 % formalin within a month of collection.

Invertebrate samples were sorted at the Ministry of Environment Fisheries Research Hatchery, Abbotsford. Samples were sorted by hand at 10 X magnification and total invertebrate wet weight measured. Total invertebrate wet weight is measured using an electronic balance (accurate to 0.001 g) after blotting the organisms to remove excess preservative (Johnston et al. 1990). Benthic invertebrates collected from the artificial substrate samples and Surber samples were later identified to genus (or the lowest taxonomic group feasible) *and* enumerated. Mean

wet weights and numbers for each reach (Blackpine, T1 and T2) and the Nation River from 1994 were compared to their corresponding 1993 values (Koning et al. 1995).

Estimated Fish Growth, Abundance and Size Distribution

Adults

Fish were angled from all reaches of the mainstem Mesilinka (Blackpine, T1 and T2) through July and intensively in August. Weight, fork length, scale sample (fin rays from bull trout), tag colour, tag number, location and condition of fish at release were recorded for all angled fish. All fish > 200 mm in length were tagged using Floy anchor tags. Fish tagged in July were given blue tags and fish tagged in August were given tags colour coded to the reach from which they were captured (Blackpine - green, T1 - orange, T2 - red). The purpose for the different coloured tags in August was to facilitate a mark-recapture population estimation (see below). Tags also facilitated growth estimation upon recapture.

Fish abundance from the mainstem Mesilinka River was carried out using standardized underwater counts as described in Slaney and Martin (1987). Six experienced divers, equipped with dry suits and snorkels, swam each reach (Blackpine, T1, T2) counting and recording fish species, length (100 mm increments), presence of tags and colour of tag if present. Each reach was replicated once (2 swims per reach) and all underwater counts took place the week of 14 August. Fish densities were calculated from expanded underwater counts and reach areas. Underwater counts were expanded to account for mid-channel regions not covered as described in Slaney and Martin (1987). Reach areas were calculated from lengths (Koning et al. 1995) and mean measured wetted widths. A ratio of fish tagged with 1994 tags (excluding blue tags) to all other fish was used as a second estimate of fish populations using mark-recapture methods. Blue tags were excluded because fish tagged prior to 1 August (blue tag) may have had a higher probability of mortality or migration than those tagged later. Therefore, only fish tagged two weeks prior to the underwater swim were considered within the tagged pool.

Size distributions of fish were estimated from both angling data (weight, length and age) and underwater counts (length and abundance) for the mainstem Mesilinka and from angling data only for the Nation River. Size distribution of adult fish from the tributaries was limited to captures while electrofishing for juveniles (see below). Age of angled fish was estimated from scale samples for rainbow trout, Arctic grayling and mountain whitefish using the technique outlined in Ward and Slaney (1988).

Juveniles (mainstem Mesilinka and Tributaries only)

Size distribution of juvenile fish from the tributaries or the mainstem was obtained from electroshocking suitable rearing habitat in each site. Culvert, Gopherhole and Control creeks were shocked twice during the summer (mid-July and early September). Fatfish and Carina creeks along with several side channels and river margins of the mainstem were shocked once

during the summer (late August or early September). Species, fork length, weight, and condition at release were recorded for all rainbow trout, bull trout, Arctic grayling, mountain whitefish, sucker, or cyprinid caught. Lengths and weights were recorded for only a sub-sample of sculpins because of the large number being caught; however, all sculpins were enumerated. Length of channel shocked and shocker time was recorded from all shocking runs. Wetted widths at 10 m intervals were recorded for all shocking runs from the tributaries. Catch-per-unit-shocker-effort was calculated for each shocking run.

Abundance estimates of juvenile rainbow trout, bull trout and mountain whitefish were carried out on Culvert, Control and Gopherhole creeks. Abundance was estimated using Peterson mark-recapture techniques. A 100-200 m section of good rearing habitat was isolated with upstream and downstream stop nets. Fish were captured by electroshocking and marked with a caudal fin clip (see below) and their length taken (marking phase). Marked fish were released back into the stream over the length of the channel shocked, excepting 25 m directly above the downstream stop net. The recapture phase occurred approximately 2.5 hours after releasing the marked fish. During the recapture phase the channel was shocked with the same effort as the marking phase; total shocker time was kept roughly equal for both shocking runs. Recaptured fish were weighed, measured and presence of fin clip noted. Total salmonid abundance (rainbow trout, bull trout and mountain whitefish) was calculated using the modified Peterson mark-recapture estimation:

$$Estimated\ Abundance = \frac{(M+1)\cdot(C+1)}{(R+1)}$$

where M is the number of individuals marked in the first sample, C is the number of individuals captured in the second sample and R is the number of recaptures. Density was calculated by dividing total abundance by the area shocked; area shocked was calculated by multiplying length between stop nets with mean wetted width.

Caudal fin clips from previous years mark-recapture estimates in the tributaries have been observed on fish caught from the mainstem. Therefore, differential fin clips were used in each creek in 1994 to allow recaptured fish to be assigned to their juvenile rearing habitat. The fin clips used were: upper caudal clip for Control Creek, lower caudal clip for Gopherhole Creek, and both upper and lower caudal clips (double clip) for Culvert Creek.

Stable Isotope Analysis

Stable isotopes of nitrogen (N) and carbon (C) can be used to determine information on source-sink and process relations (Peterson and Fry 1987). The movement (source-sink relation) of N, from artificial fertilizers, through a food web can be observed by examining the ratio of $^{15}N:^{14}N$ at different food web levels (Peterson et al. 1993b). ^{15}N and ^{14}N are stable isotopes of

nitrogen that occur naturally in the environment. The ratio of $^{15}N:^{14}N$ can be significantly different between natural N sources and artificial fertilizers and the fractionation of the artificial fertilizers can produce further shifts in the natural $^{15}N:^{14}N$ ratio (Peterson et al. 1993). Therefore, N isotopic ratios can be used to trace N, and hence food web, sources in an organism provided baseline ratios are known under natural and fertilized conditions (Peterson et al. 1993b). The primary source (source-sink relation) of C in an aquatic food web can also be examined by determining ratios of $^{13}C:^{12}C$ (Fry 1991). Aquatic algae and terrestrial plant detritus can have distinctly different ratios of $^{13}C:^{12}C$ and little isotopic fractionation of carbon isotopes occurs across trophic levels (Fry 1991). Therefore, the $^{13}C:^{12}C$ ratio can reflect whether the carbon source for an organism is primarily from the transport of terrestrial organic matter or from within stream production of algae. Finally, trophic positions of organisms (process relations) can be determined from N isotopes (Peterson and Fry 1987). Isotopic fractionation of N occurs during trophic transfers resulting in a net increase of 3 to 5 parts per thousand ^{15}N at each food web level (Peterson and Fry 1987). Hence, if the $^{15}N:^{14}N$ ratio of algae is known then the trophic position of other organisms can be estimated from their $^{15}N:^{14}N$ ratio given this relation (Peterson and Fry 1987).

Stable N and C ratios in food webs from the Mesilinka River were analyzed so as to trace the fate of introduced fertilizers, determine primary C sources and examine the trophic relations of organisms. Sampling was conducted under the supervision of B. Peterson and L. Deegan, research scientists from The Ecosystem Centre at Woods Hole, Massachusetts. Organisms (algae, invertebrates and fish) at each food web level were sampled from the Mesilinka River. Samples were collected from 2 sites (2 km and 1 km) upstream of the upper fertilizer station (Rc.adend; Fig. 2), 2 sites (1.5 km and 4.5 km) downstream of the upper station and 1 site downstream of the lower fertilizer station (mid-launch, 35 km downstream from the upper fertilizer station). Algae were collected by scraping periphyton from rocks and concentrating them on glass fibre filters. Mosses, willows and alders were sampled as terrestrial vegetation. Invertebrates were sampled from riffle regions using a drift net and hand picking from the substrate. Juvenile fish were sampled by electroshocking and adults by angling. Baseline $^{15}N:^{14}N$ ratios for the fertilizer were obtained by sampling fertilizer at the upper station (both 28-0-0 and 10-34-0). All samples were frozen in dry ice within 12 hours of collection. Samples were transported frozen to The Ecosystem Centre, Woods Hole for analysis. $^{15}N:^{14}N$ ratios will be determined using mass spectrometry (Peterson et al. 1993b). N and C isotopic compositions are expressed as 6 values which represent the difference between the sample and a standard using the equation:

$$\delta X = [(R_{sample}/R_{standard}) - 1]$$

where X is ^{13}C or ^{15}N and R is the corresponding ratio ($^{13}C:^{12}C$ or $^{15}N:^{14}N$) for either the sample or a standard (Peterson and Fry 1987). Standard references are carbon in PeeDee limestone and nitrogen gas in the atmosphere (Peterson and Fry 1987).

RESULTS AND DISCUSSION

Weather

Daily air temperatures from Germansen Landing ranged from a low of -8.5°C in late October to a high of 33°C in late July (Fig. 7). Mean daily temperatures increased from an average of 8°C in May to 15.7°C in July and back down to 2.5°C by October. Mean daily temperatures recorded from Germansen Landing in 1994 were significantly correlated with temperatures recorded near the Mesilinka River for the same period (R^2=0.71,P<0.001,N=24). However, mean daily temperatures recorded from the Mesilinka River were approximately 0.5-2 °C warmer than those recorded from Germansen Landing (Fig. 8).

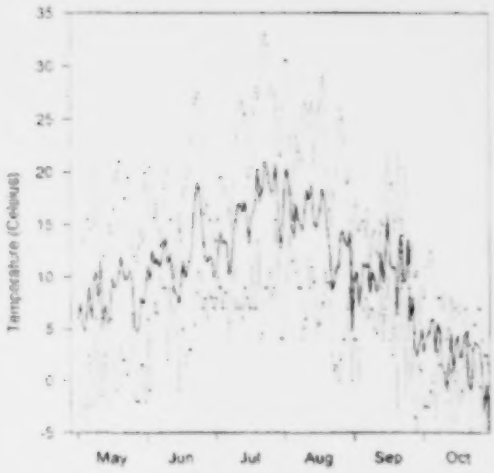

Figure 7 - Maximum, mean and minimum daily air temperatures from Germansen Landing.

Hydrology

Daily discharge from the Mesilinka River in 1994 differed from discharge patterns for 1992 and 1993 (Fig. 9; Koning et al. 1995). Spring run-off in 1994 was characterized by four distinct and roughly equal freshets from mid-May to mid-July (Fig. 9); whereas, run-off in 1992 was dominated by one distinct freshet tapering off during early July (Koning et al. 1995). Maximum flows in 1992 and 1993 were higher (350 and 250 m^3s^{-1}, respectively; Koning et al. 1995) than in 1994 (185 m^3s^{-1}; Fig. 9). Discharge, on average, decreased to levels less than 60 m^3s^{-1} between late July to mid-September (Fig. 9) which corresponds to discharge levels for the same time in 1992 and 1993 (Koning et al. 1995).

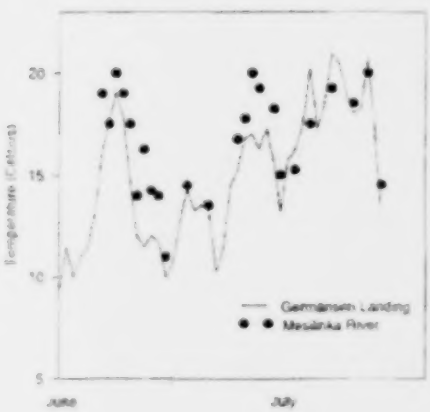

Figure 8 - Comparison of mean air temperatures between Germansen Landing and the lower Mesilinka River.

Daily discharge for the lower Mesilinka River was estimated using the equation:

$$Y = 10^{(.8103 \cdot 1.557)} \quad R^2 = .94$$

where Y is the discharge (m^3s^{-1}) at the WSC station and X is the staff gauge reading (m) at Blackpine. Predicted discharge from the equation did not differ significantly from WSC discharge values ($P > 0.70$, $N = 11$). Predicted discharge values from the above equation were used to calibrate fertilizer drip rates to achieve target loadings.

Discharge from the 5 tributaries peaked in late June and early July (Fig. 10) due to a combination of heavy rains and melting of the alpine snowpack. Discharge from Control, Culvert and Gopherhole creeks were similar with the late June freshet (3-4.5 m^3s^{-1}) quickly falling to flows less than 1 m^3s^{-1} by mid-July (Fig. 10). Flows from Carina Creek experienced a similar freshet in late June; however, flows following the freshet declined more slowly and did not fall below 1 m^3s^{-1} (Fig. 10). Moderated flows from Carina Ck. result from two lakes (Tomias and Carina) in its headwaters and several swamps near its mouth that regulate its flow. Flows from Fatfish Ck. were always < 1 m^3s^{-1} even during the late June freshet (Fig. 10). Low flows from Fatfish Ck. reflect the small size of this creek. Predicted discharge values for 1994 from the tributaries using stage-discharge relationships from 1993 did not differ significantly from measured values in 1994 (Table 1).

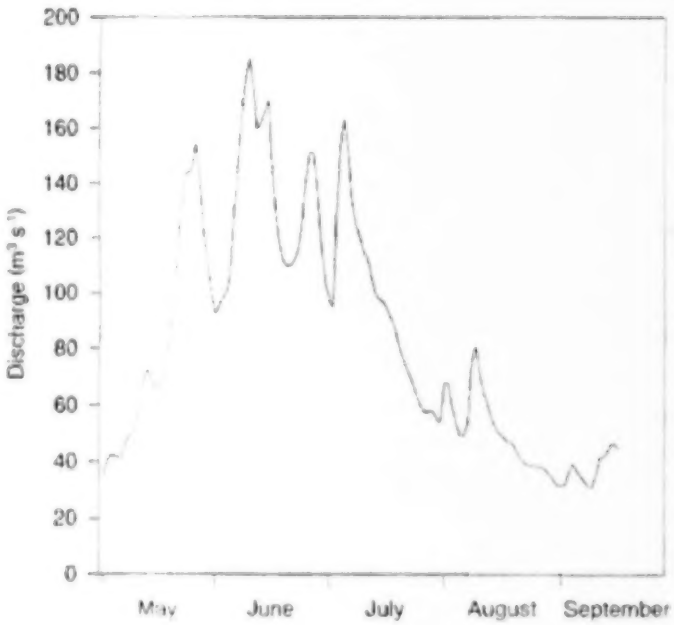

Figure 9 - Daily discharge (1994) from the Mesilinka River measured by WSC.

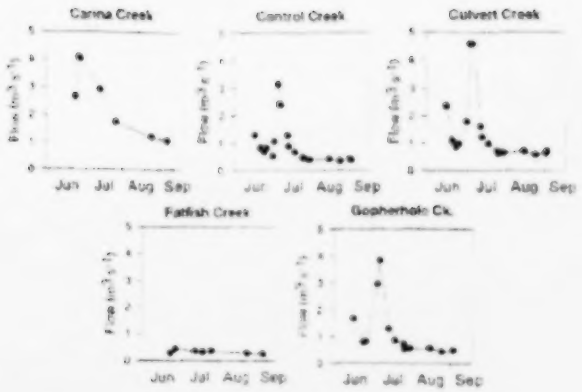

Figure 10 - Discharge from 5 tributaries of the Mesilinka River.

Table 1 - Water level (m) - flow(m^3B^{-1})relationships for the 5 tributaries (Koning et al. 1995). Squared correlation coefficients (R^2) are shown for the equations. Probabilities (P) are shown for the comparison between predicted and measured values. Sample sizes (N) are shown for both equations and statistical tests.

Tributary	Equations	Wilcoxon test
Gopherhole Creek	Flow = $10^{(2.516(\text{water level}) - 0.906)}$ N = 14 $R^2 = 0.93$	N = 4 $P > 0.12^{n.s.}$
Fatfish Creek	Flow = $10^{(1.524(\text{water level}) - 1.107)}$ N = 6 $R^2 = 0.72$	--
Carina Creek	Flow = $10^{(0.534(\text{water level}) - 0.026)}$ N = 6 $R^2 = 0.73$	--
Control Creek	Flow = $10^{(3.920(\text{water level}) - 1.896)}$ N = 10 $R^2 = 0.99$	N = 5 $P > 0.06^{n.s.}$
Culvert Creek	Flow = $10^{(3.371(\text{water level}) - 0.651)}$ N = 14 $R^2 = 0.96$	N = 5 $P > 0.06^{n.s.}$

n.s. - not significant

Water Temperatures

Water temperatures from the max/min thermometer at one site on the Mesilinka River (lower fertilizer; Fig. 3) varied from a low of 9°C to a high of 17°C between the beginning of July and end of August (Fig. 11). Mean temperatures for this period ranged from 10.5-14°C with an average of 12°C in July and 13°C in August (Fig. 11).

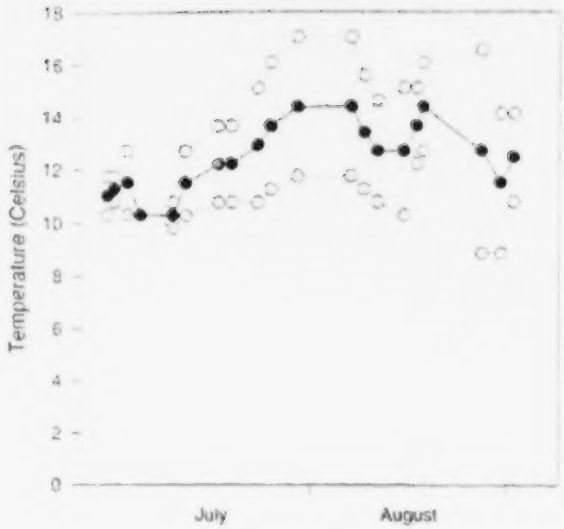

Figure 11 - Maximum, minimum and mean water temperatures from a max/min thermometer located at the lower fertilizer site.

Water temperatures from the upper sites on Culvert and Gopherhole creeks were lower than on the Mesilinka River. Temperatures from upper Gopherhole Creek ranged from a maximum of 13.5°C to a minimum of 4.5 °C between July and August. Mean temperatures during this period were 9°C. Temperatures at upper Culvert Creek ranged from 11.5°C to 6.5°C with a mean of 9°C. Water temperatures from the thermographs are summarized in detail in Langston (1994).

Mainstem Mesilinka Fertilization

Estimated summer loadings of P and N at the upper fertilizer station (Roadend) were on average lower than the respective target concentrations of 5 and 15 μg L^{-1} (Fig. 12). Mean estimated loadings were 4.5 μg P L^{-1} and 9.0 μg N L^{-1} (Fig. 12). Strong fluctuations in N loadings (Fig. 12) reflect problems encountered with regulating the flow of 28-0-0. For example, drip rates could fall from target rates (e.g. 58.5 ml min^{-1}) to nominal rates 2 days later (e.g. 5.5 ml min^{-1}). The decrease in drip rates was likely the result of an observed precipitate within the main storage tank and in the connecting hose that would plug the regulating valve. The assumption that drip rates changed linearly between consecutive readings is likely wrong for 28-0-0 as rates would have dropped when the precipitate clogged the valve. Later in the summer as more precipitate formed within the storage tank clogging likely occurred more quickly. Therefore, actual N loading may be lower than predicted, especially later in the summer (Fig. 12). Although P loading rates varied (Fig. 12), drip rates remained relatively constant over the

summer. Variation in P loadings (Fig. 12) are mainly the result of daily changes in river discharge. Loading of P at the lower fertilizer station was more variable and on average lower

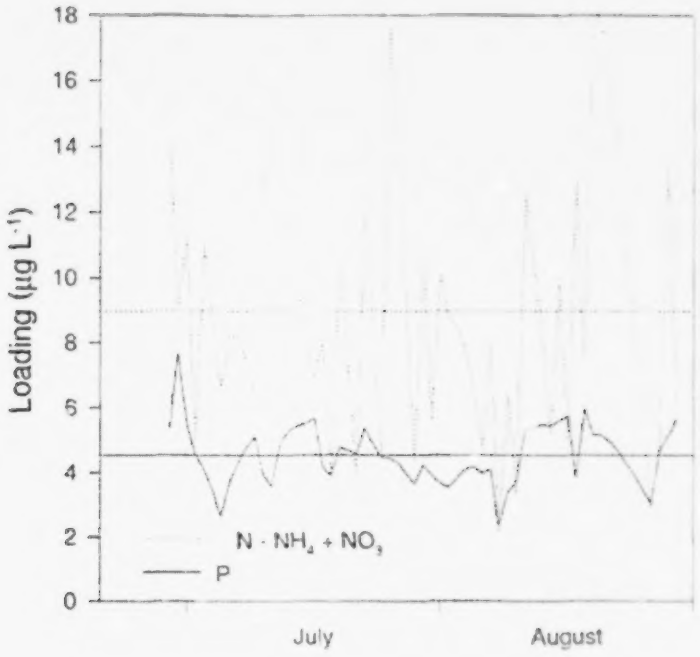

Figure 12 - Estimated daily loading of P and N at the upper fertilizer station (Roadend). Mean loading rates are shown by the horizontal lines.

than the P loading at the upper fertilizer station (Fig. 13). Mean estimated loading was 3.6 µg P L^{-1} (Fig. 13). Nitrogen loading varied according to P as both were added in combination (10-34-0). Mean loading of N was 2.4 µg L^{-1} (Fig. 13). Variation in loading rates were a combination of changes in discharge from the Mesilinka River and drip rates. Changes in drip rates at the lower station were never as severe or consistent as described above for 28-0-0 (drip rates rarely fell below 50% of the target rate); however, rates were more variable than the 10-34-0 rates at Roadend. One possible explanation for the greater variation in drip rates with 10-34-0 at the lower site is the difference in layout of the connecting hoses. At the lower site the connecting hose ran steeply downhill from the storage tank to the drip valve; whereas, at the upper site the connecting hose dropped very little. Small amounts of dirt and debris present in all the storage tanks may have settled out in the connecting hose at the upper site before reaching the drip valve.

At the lower site gravity would have helped draw particles towards the drip valve causing it to clog more frequently.

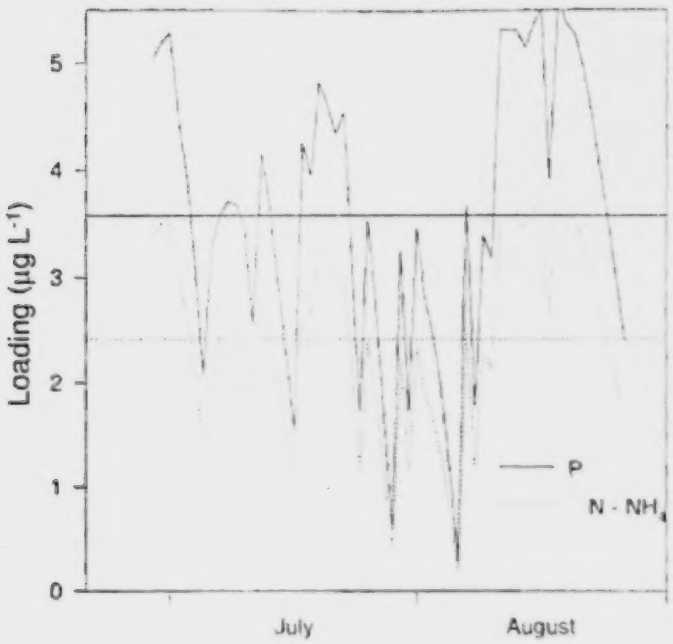

Figure 13 - Estimated daily loading of P and N at the lower fertilizer station. Mean loading rates are shown by the horizontal lines.

The total amount of fertilizer added to the Mesilinka River over the summer was approximately 10 tonnes of 28-0-0 at Roadend, 29 tonnes of 10-34-0 at Roadend and 29 tonnes of 10-34-0 at the lower fertilizer site. This equates to 5.7 tonnes of N and 9.9 tonnes of P being added at Roadend and 2.9 tonnes of N and 9.9 tonnes of P added at the lower fertilizer site.

Water Chemistry

Concentrations of SRP in the mainstem Mesilinka and Nation rivers increased above detectable levels (1 µg L^{-1}) during two of five sampling periods through the summer (Fig. 14). The first period in mid-July likely represented increased transport of dissolved P from the watershed following the early July freshet observed in the 5 tributaries. The second period occurred on the last sampling date in early September (Fig. 14). SRP values were greatest during

these periods in the treatment reaches T1 and T2 than either the control reach (Blackpine) or the external reference (Nation: Fig. 14). Infrequent differences in SRP between the treated and untreated reaches likely resulted from rapid nutrient uptake throughout most of the summer which was able to remove most of the available P (including that added by fertilization).

NO_3+NO_2-N concentrations on average decreased through the summer in the Mesilinka River (Fig. 14). Values ranged from a high in all reaches of 20 µg L^{-1} on the 21 June 94 to levels below the detection limit (5 µg L^{-1}) in early September (except T1: Fig. 14). NO_3+NO_2-N dropped below 10 µg L^{-1} in T2 following the start of fertilization (28 June 94) indicating that N was likely limiting following P fertilizer addition (Fig. 14). Higher values of NO_3+NO_2-N in T1 were likely the result of the NH_4NO_3 fertilization, in addition to P, that alleviated N limitation, except during late August (Fig. 14). In 1992, NO_3+NO_2-N did not drop below 10 µg L^{-1} in any reach of the Mesilinka as P was likely the limiting nutrient in this year (Koning et al. 1995). NO_3+NO_2-N in the Nation River was low throughout the summer decreasing from a high of 8 µg L^{-1} in June and July to below detection limits in August (Fig. 14).

Concentrations of NH_4-N followed an opposite trend than NO_3+NO_2-N increasing from below detection limits (5 µg L^{-1}) in June and July to a high of 16 µg L^{-1} in the Nation River in late August (Fig. 14). NH_4-N was also highest (7-8 µg L^{-1}) in late August for the two treatment reaches (T1 and T2) of the Mesilinka River (Fig. 14). Levels in the control reach (Blackpine) did not increase above detection limits throughout the summer.

Total organic nitrogen (TON) decreased throughout the summer in the Mesilinka and Nation rivers (Fig. 14). Decreasing values were likely a function of discharge and run-off from the watershed. TON was greatest in the Nation River, which has a larger watershed and is headed by a series of lakes. TON was lowest in the control reach (Blackpine) of the Mesilinka River, dropping to detection limits (40 µg L^{-1}) by the first sampling date in July (Fig. 14).

SRP in all the tributaries showed a peak during the first sampling period in July with values constantly 2 to 4 fold lower during other sampling periods (Fig. 15). A comparison of SRP values with discharge for the tributaries shows a positive trend of increasing dissolved P with increasing discharge. A positive relation between dissolved P and discharge may indicate that P from "near-surface" inputs are higher (ie. P rich soils) than from "deep-seepage" inputs (Praire and Kalff 1988).

Inorganic N (NO_3+NO_2-N and NH_4-N) and TON did not show any strong seasonal trends (Fig. 15). NH_4-N was below detection limits for all tributaries except on one occasion in each of Gopherhole and Control creeks (Fig. 15). NO_3+NO_2-N fluctuated around a mean value for each of the tributaries throughout the summer (Fig. 15). Mean NO_3+NO_2-N values

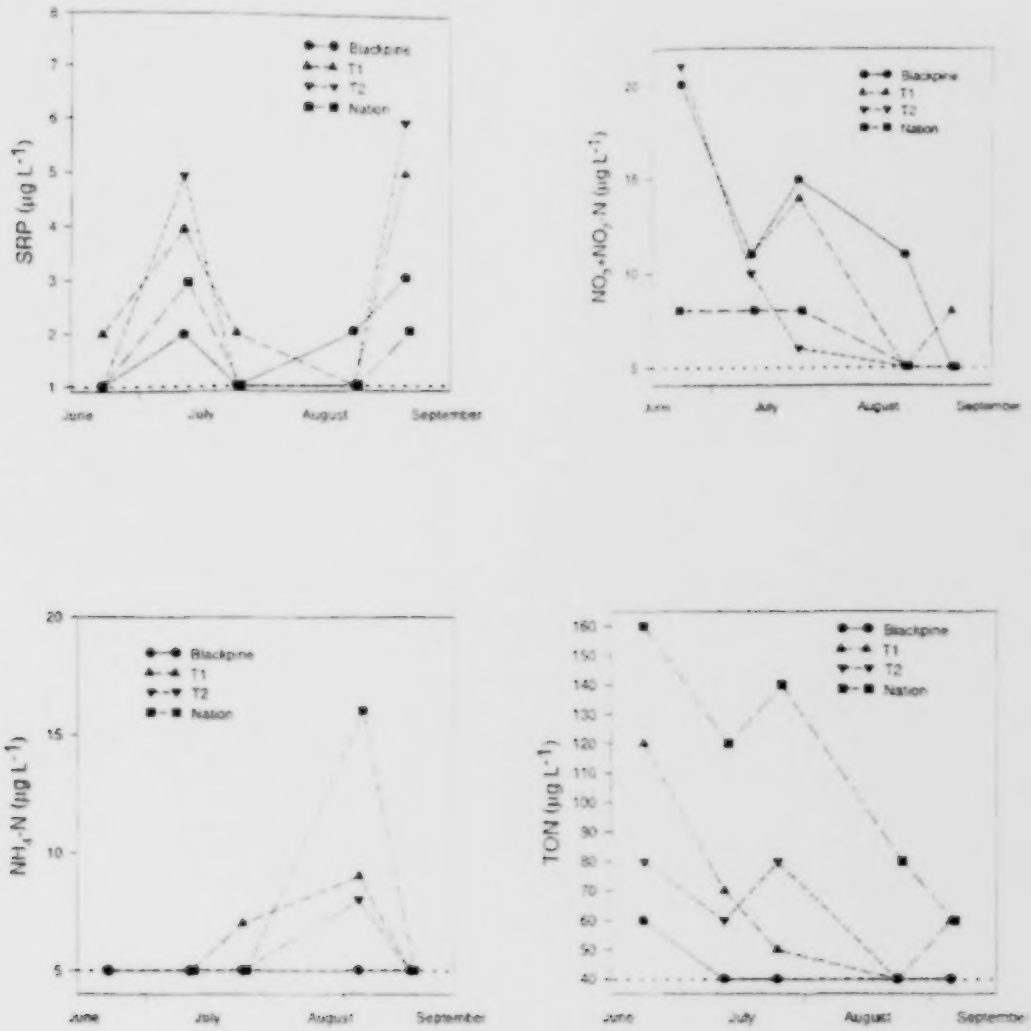

Figure 14 - SRP, NO_3+NO_2-N, NH_4-N, TON from the Mesilinka and Nation rivers (1994). Minimum detectable limits shown by dashed line.

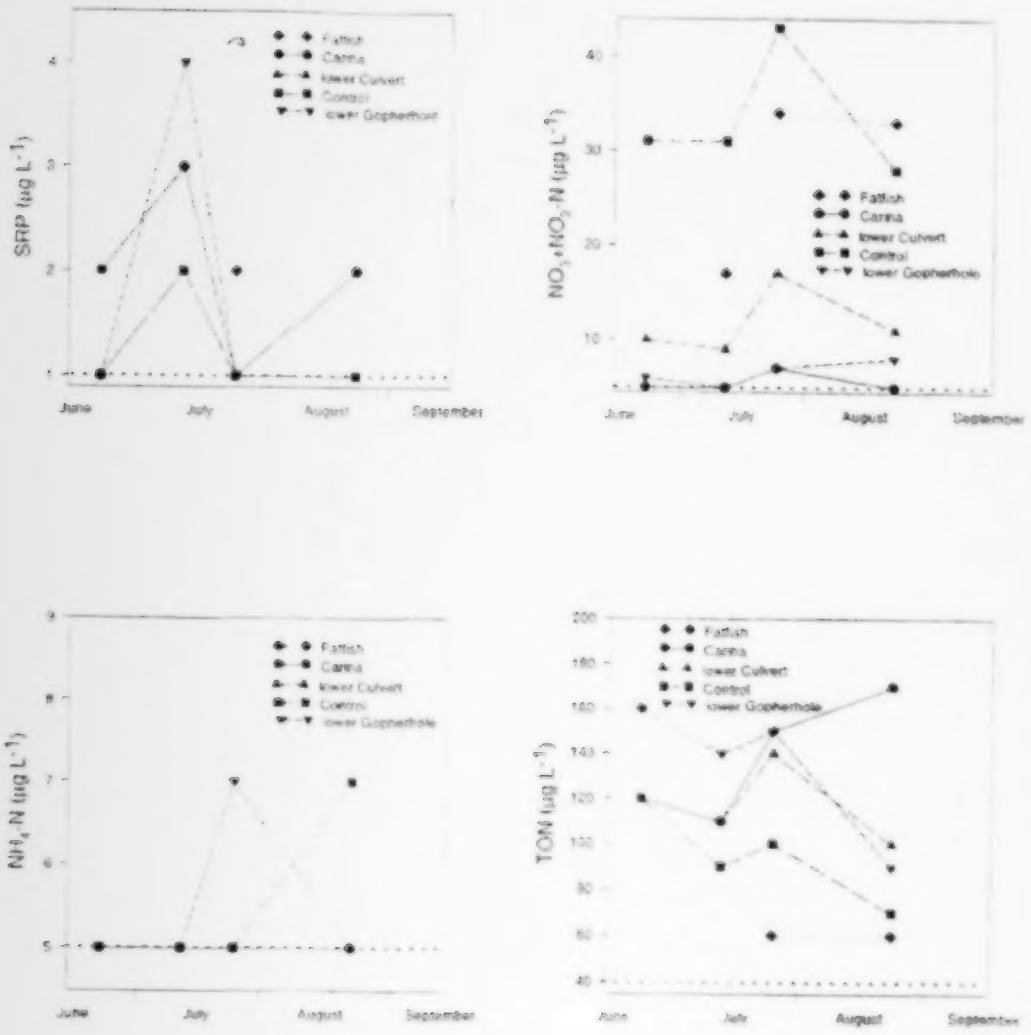

Figure 15 - SRP, NO3+NO2-N, NH4-N and TON from 5 tributaries of the Mesilinka River (1994). Minimum detectable limits shown by horizontal dashed line.

were 33.2, 28.8 and 11.8 µg L^{-1} for Control, Fatfish and lower Culvert creeks, respectively. Mean values for lower Gopherhole and Carina creeks were not calculated as they fluctuated around detection levels. TON in the tributaries ranged from a low in Fatfish of 60 µg L^{-1} to a high of 170 µg L^{-1} in Carina.

Periphyton Accrual

Accrual of chlorophyll a was greatest in the two treatment reaches (T1 and T2) than in the control reach (Blackpine), immediately above the upper fertilizer station (Roadend) or the Nation River (Fig. 16). Mean areal chlorophyll a was an order of magnitude higher in T1 (127.5 mg m^{-2}) than unfertilized locations on the Mesilinka River or Nation River (range 10.8-15.3 mg m^{-2}; Fig. 16). Chlorophyll a was 2 fold higher in *12* (29.7 mg m^{-2}) than for the unfertilized locations (Fig. 16). Peak areal chlorophyll a values for the Mesilinka River from 1992 and 1993 (range 12-15 mg m^{-2}; Koning et al. 1995) are similar to unfertilized locations in 1994. Higher chlorophyll a values for T1 and T2 in 1994 must be attributed to the fertilizer addition. Added nutrients in other systems have been shown to increase areal chlorophyll a up to 5 fold in experimental enclosures (Bothwell 1989) and in whole stream experiments 5 to 10 fold (Peterson et al. 1985; Perrin et al. 1987; Slaney and Ward 1993).

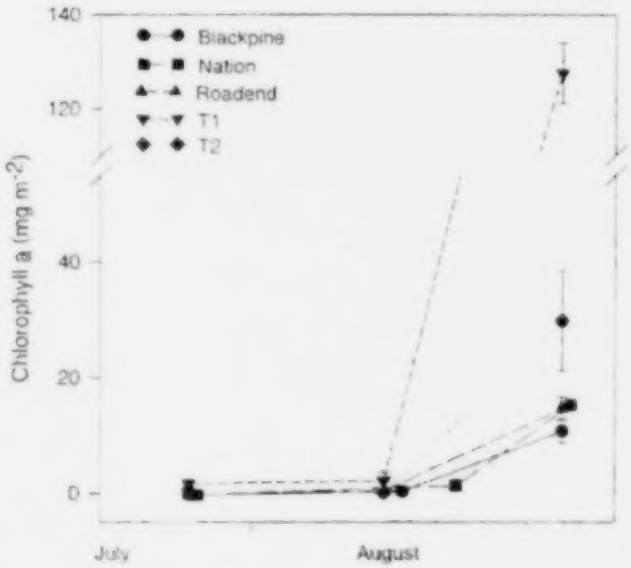

Figure 16 - Accrual of chlorophyll a on artificial substrate from 4 locations in the Mesilinka River and 1 location in the Nation River. Error bars are 1 standard error of the mean.

Increased algal biomass from fertilization was visually observable during routine travel along each of the treatment reaches of the Mesilinka River. A band of filamentous algae 5-10 m wide and present below both fertilizer stations was observed from the surface and underwater.

The presence of an algal band may indicate that complete horizontal mixing of fertilizers may not occur for some distance downstream. Investigations into point source discharge of pollutants in rivers indicate that it takes on the order of 100 times the rivers width to achieve complete horizontal mixing (Smith 1987). Therefore, complete horizontal mixing of added fertilizers on the Mesilinka River may be around 5.2 km and 3.7 km for T1 and T2 respectively. However, the actual downstream distance for complete horizontal mixing to occur will depend on discharge, stream topography and the location of fertilizer inputs (Smith 1987). Further study should be spent on patterns of nutrient dispersal given different input sites and topography of the Mesilinka River. For instance, nutrient utilization will increase if nutrient spiralling length is decreased (Newbold et al. 1981); and, decreased spiralling length is likely related to decreased water velocity (Newbold et al. 1981). Therefore, optimal patterns of nutrient release may be to increase nutrient utilization in regions of lower stream velocity, such as along shorelines. Finally, the presence of algal bands below the fertilizer sites may also be the result of differential patterns of grazing insects or UV radiation.

The higher areal chlorophyll a reached in T1 as compared to T2 (Fig. 16) may be explained by at least 4 hypotheses. First, the location of the periphyton blocks in T1 immediately downstream of Carina Creek (Fig. 5) undoubtedly provided an additional source of nutrients, as was evident from natural periphyton growth on the rocks. P loading from Carina Creek will be high given its SRP concentrations during early summer (Fig. 15) and the magnitude of its discharge (Fig. 10). However, periphyton blocks located in T1 during 1993, approximately 500 m upstream of 1994 locations but still below the outflow of Carina Creek, did not differ in peak chlorophyll a values from other reaches (Koning et al. 1995). Second, the location of the lower fertilizer station from T2 is much farther than the upper fertilizer station is from T1 (Fig. 2). Since nutrient uptake is likely to occur quickly, periphyton growth in T2 may have been more reliant on downstream spiralling of nutrients (Newbold et al. 1981). The downstream transport of fertilizers will decrease with spiralling as nutrients are lost to sedimentation. Third, differences in periphyton accrual between T1 and T2 may be explained by the mean P loading from each of the fertilizer stations. Mean P loading was greater ($4.5 (\mu g L^{-1})$ at the fertilizer station above T1 than the fertilizer station above T2 ($3.6\ \mu g\ L^{-1}$). Fourth, periphyton growth may have been limited by N in T2. Levels of inorganic N were lower in T2 than T1 (Fig. 15). Finally, all 4 hypotheses may have been acting in conjunction to produce small differences in nutrient concentrations between T1 and T2. Small differences in nutrient concentrations could have translated into large differences in periphyton biomass especially during late August when P levels were $< 1\ \mu g\ L^{-1}$. Peak periphyton biomass increases rapidly with P (Monod type growth kinetics) at concentrations below $1\ \mu g\ L^{-1}$ (Bothwell 1989). These hypotheses can be further examined in future years using additional periphyton blocks upstream of Carina Creek and closer to the lower fertilizer site.

Accrual of chlorophyll a from the tributaries was similar for most tributaries (Fig. 17). Measured peak areal chlorophyll a from Carina, Control, and both Gopherhole sites varied from a high in Carina ($39.2\ mg\ m^{-2}$) to a low in upper Gopherhole ($26.9\ mg\ m^{-2}$). Peak values for Culvert Creek were 5 fold lower ($7.3\ mg\ m^{-2}$) than values for the other creeks. A similar

observation was made in 1992 with peak chlorophyll a values in Culvert Creek 3-4 fold lower than Control or Gopherhole creeks (Koning et al. 1995). Peak chlorophyll a from Culvert Creek in 1993 was similar to the mean of all creeks (Koning et al. 1995). Fertilizer was added to Culvert Creek in 1993 (Koning et al. 1995). However, the increase in 1993 may not have been a result of fertilizer additions because the highest accrual of chlorophyll a in Culvert Creek was upstream of the fertilization input. Peak areal chlorophyll a for Fatfish Creek, for 1995, is unavailable as the styrofoam plate broke away before the final sampling date.

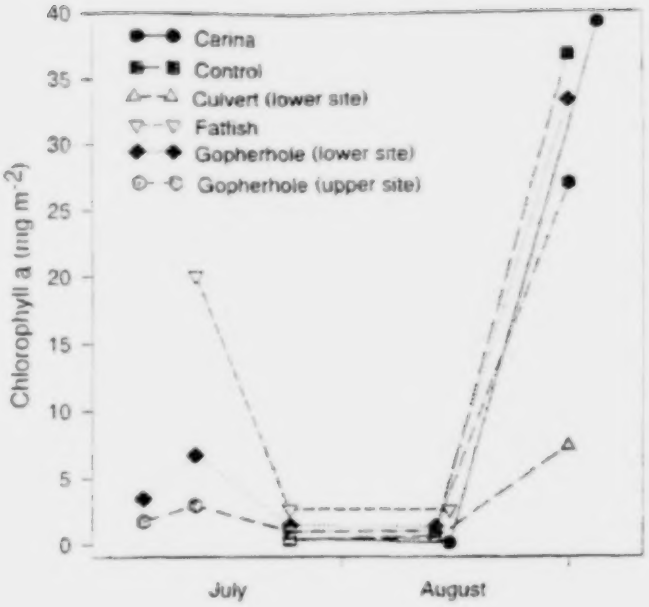

Figure 17 - Accrual of chlorophyll a on artificial substrate in 5 tributaries of the Mesilinka River.

Chlorophyll a values for all periphyton blocks did not show any increase between mid-July and mid-August (Fig. 16 and 17). In fact, periphyton blocks from the tributaries, that did not wash out in early July, showed a decline in areal chlorophyll a in mid-July. Values for many of the blocks were below detection limits for this period. A similar observation has been made from other systems (Perrin et al. 1987) and several hypothesis have been proposed including UV exposure, insect grazing, cell lysis by bacteria, micronutrient supply or changes in flow (Perrin et al. 1987). Periphyton accrual in 1992 and 1993 for the Mesilinka River did not show this trend and increased throughout the summer (Koning et al. 1995). It is possible that periphyton growth was limited during mid-summer of 1994 by UV-B radiation directly or an interaction between grazing insects and UV-B radiation. This hypothesis can be tested in future years with the use of UV opaque plexiglass installed on a subset of periphyton blocks.

Benthic Invertebrates

Wet weights of benthic invertebrates increased from 1993 to 1994 in T1, T2 and the Nation River (Fig. 18); but, the observed increase was not statistically significant in T1 or T2 and the Nation River was not tested (Table 2). Invertebrate wet weights for Blackpine showed almost no increase between the two years (Table 2; Fig. 18). The absence of a statistically significant response for benthic invertebrate wet weights in T1 and T2 is likely due to the low power of the test (Table 2). The power of a test (ie. the ability, or probability, to detect an effect when in fact an effect occurs) is dependent on several factors including population and sampling variability, sample size and type of statistical test used (Sokal and Rohlf 1981). For instance, if natural variability within a population is high then even if a biologically relevant effect has occurred it may be obscured within this variability. The low power indicated for Blackpine (0.048) results from the similarity in means between the two years (Table 2). However, although both T1 and T2 show more than a doubling in wet weights from 1993 to 1994, there is approximately only a 3 in 10 chance of detecting a statistical difference given the variability associated with these means (Table 2; Fig. 18). The power for the test can be increased by increasing the sample size (Sokal and Rohlf 1981). Therefore, we recommend that the number of benthic baskets be increased to 20. This will increase the power of the test to 80% given the variability and observed difference in means (log_{10} transformed) between these years for T2 (Table 2).

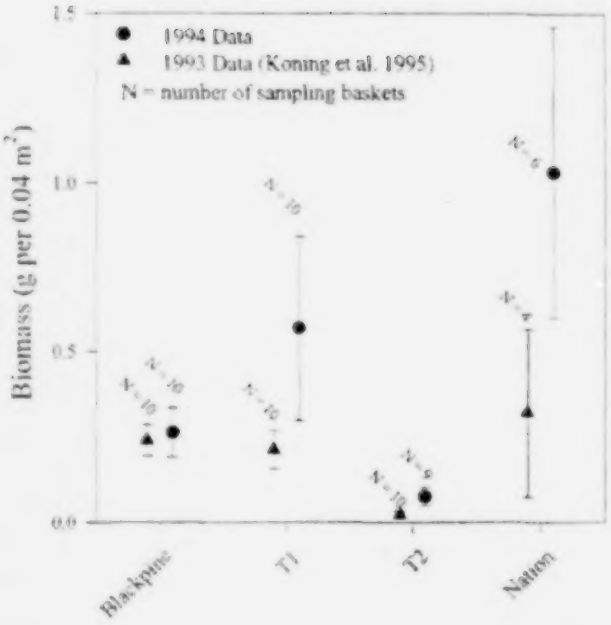

Figure 18 - Mean wet weight of benthic invertebrates from artificial substrate baskets. Error bars are 1 SE of the mean.

Table 2 - Mean wet weights of benthic invertebrates from artificial substrate baskets for 1993 and 1994. Differences between years for each site was statistically tested using a t-test, with significance set at $P < 0.05$. Data were $\log_{10}$ transformed to meet the assumptions of normality and equal variance for the statistical test. The power of the test is also shown.

Location	Year	Mean (untransformed data)	P	Power
Blackpine	1993	0.239	0.814	0.048
	1994	0.262		
T1	1993	0.212	0.251	0.251
	1994	0.570		
T2	1993	0.022	0.073	0.322
	1994	0.075		
Nation	1993	0.319	not tested*	not calculated*
	1994	1.030		

* - assumptions of normality and equal variance not met

The numerical abundance of some groups of benthic invertebrates increased in the treatment reaches (T1 and T2) during 1994 when compared to 1993 numbers (Fig. 19). The largest difference occurred in T1 for Dipteran larvae (ie., true flies) which showed almost an order-of-magnitude increase in 1994 over 1993 (t-test, data $\log_{10}$ transformed, $P < 0.002$; Fig. 19). Previous fertilization experiments (Peterson et al. 1985; Johnston et al. 1990; Slaney and Ward 1993) have all shown responses in benthic insects within the first summer of fertilization. The increased abundance of Dipterans between 1994 and 1993 for T1 can be almost entirely attributed to species from the sub-Family Orthocladiinae (Family Chironomidae). Hershey et al. (1988) showed that mean length and densities of Orthocladius rivulnrum (sub-Family Orthocladiinae) increased following fertilization in the Kuparuk River, Alaska. However, increased densities of Orthocladius in the Kuparuk River were limited to areas immediately downstream of fertilization input and showed a one-year time lag following the start of fertilization (Hershey et al. 1988). A response in Orthcladiinae species in the first-year of fertilization for the Mesilinka River (Fig. 19) may indicate that they produce multiple generations each summer; whereas, Orthocladius rivulorum in the Kuparek River produce only one generation each year (Hershey et al. 1988). Because the response of Orthncladius was variable from year to year in the Kuparek River, Hershey et al. (1988) hypothesized that nutrient regime was not likely the primary factor regulating densities of Orthocladius in this system.

T2 also showed an increase in Dipteran larvae from the sub-Family Orthocladiinae, although numbers were much lower than in T1 (t-test, data $\log_{10}$ transformed, $P < 0.012$; Fig. 19). Ephemeropterans (ie., mayflies) and Plecopterans (ie., stoneflies) in T2 were also more

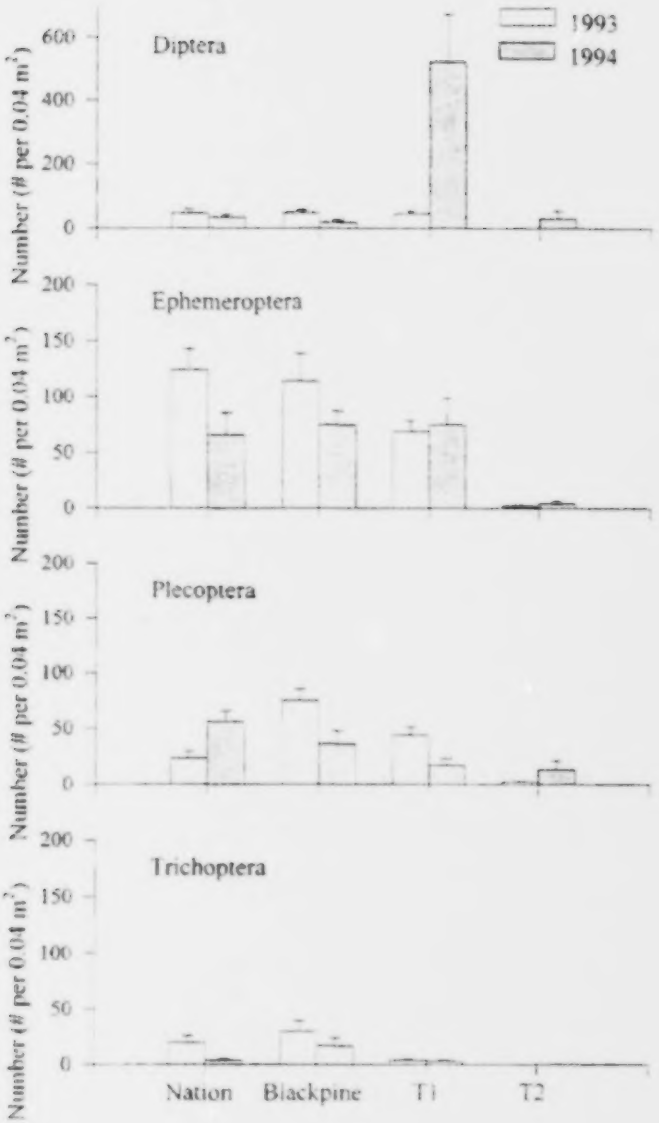

Figure 19 - Density of the major benthic invertebrates collected from basket samplers located in the Nation River and 3 reaches of the Mesilinka River. Error bars are 1 SE of mean.

abundant in the basket samples in 1994 over 1993 (Fig. 19); however, these differences were not statistically significant. Taxonomic groups (e.g., beetles, crustaceans, Annelids, etc.) other than Dipterans, Ephemeropterans, Plecopterans and Trichopterans consisted of < 1% of the total numerical composition of benthic invertebrates collected from the artificial basket samplers.

The wet weights of benthic invertebrates collected from the Mesilinka River, in 1994, differed significantly among the reaches (Blackpine, T1 or T2) but not in the method (artificial baskets versus Surber sampler) of collection (Table 3; Fig. 20). However, the difference in method of collection was only marginally non-significant ($P = 0.057$; Table 3) and the power of this test was relatively low (Table 3). Furthermore, the interaction between location and sampling method was significant (Table 3). An a posteriori multiple comparison among means (Student-Newman-Keuls test, $a = 0.05$) indicates that there is a significant difference in invertebrate wet weights from method of collection at Blackpine but not T1 or T2 (Fig. 20). This observed interaction between sampling method and location may have important implications when determining the effect of fertilization on benthic invertebrate biomass. For example, a multiple comparison among mean wet weights for the different reaches of the Mesilinka River in 1994 using the basket sampler shows significant differences between T1 versus T2, Blackpine versus T2 but not Blackpine versus T1 (Fig. 20). On the other hand, a comparison among means based on the Surber sampler results in significant differences between T1 versus T2, Blackpine versus T1 but not Blackpine versus T2 (Fig. 20). Although none of these observed differences can at present be attributed to fertilization, sampling method is important in detecting differences among reaches and should be carefully considered in future years.

The numerical abundance of benthic invertebrates collected using either the Surber or basket sampler also differed in Blackpine versus T1 or T2 (Fig. 21). Numbers of Dipterans, Ephemeropterans, Plecopterans or Trichopterans collected by either the Surber or basket sampler were not significantly different for either T1 or T2, excepting Ephemeropterans collected in T2 (Fig. 21). The Surber sampler collected significantly more Ephemeropterans in T2 than did the basket sampler (t-test, data $\log_{10}$ transformed, $P < 0.001$; Fig. 21). However, the number of Ephemeropterans (t-test, data $\log_{10}$ transformed, $P < 0.001$) and Plecopterans (t-test, data $\log_{10}$ transformed, $P < 0.001$) collected in Blackpine by the Surber sampler was significantly lower than what was collected using the basket sampler in this same reach (Fig. 21).

Table 3 - Two-way analysis of variance for $\log_{10}$ transformed wet weights of benthic invertebrates from different reaches of the Mesilinka River (Blackpine, T1 and T2) and different sampling methods (artificial basket sampler and Surber sampler) for 1994.

Source of Variation	df	MS	P	Power
Treatment				
Location	2	5.0575	< 0.001	> 0.999
Sampling Method	1	1.1480	0.057	0.360
Interaction	2	2.8371	< 0.001	0.965
Error	53			

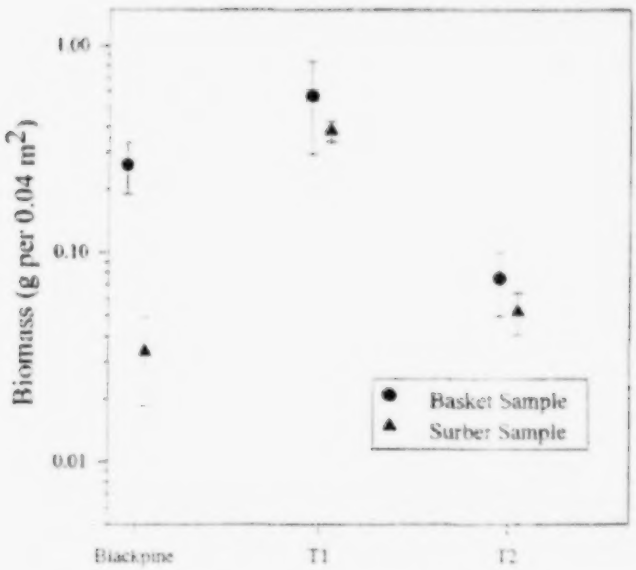

Figure 20 - Mean wet weights of benthic invertebrates from the Mesilinka River (1994) sampled using artificial substrate baskets and a Surber sampler. Error bars represent 1 SE of the mean.

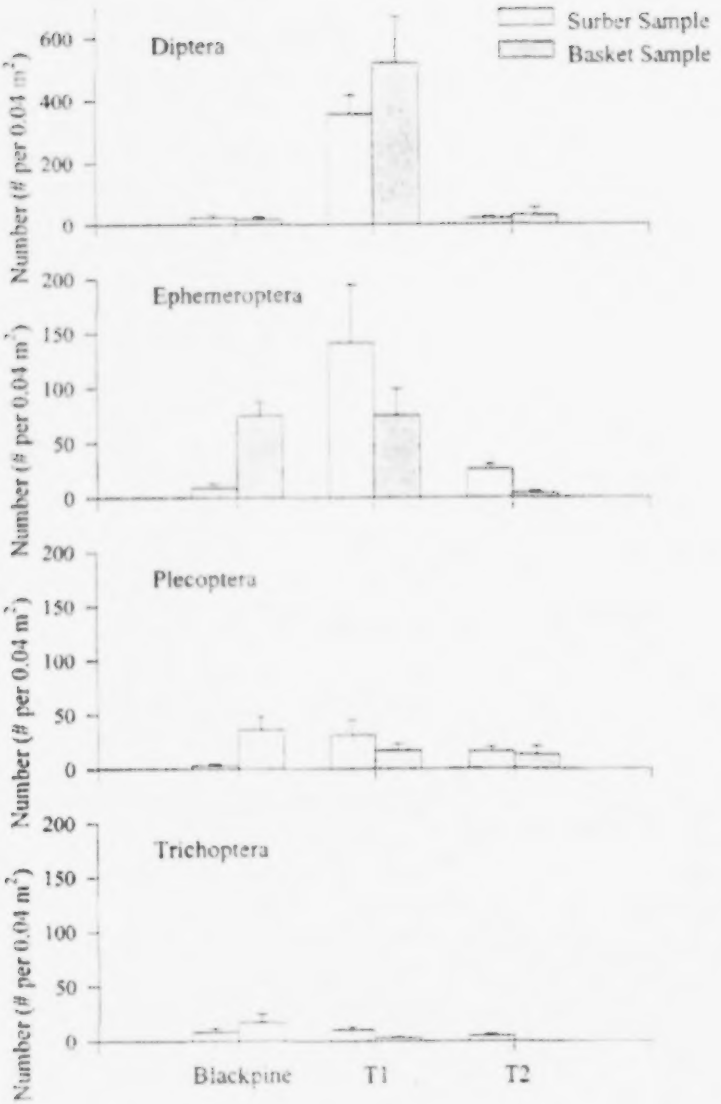

Figure 21 - Density of major benthic invertebrates collected in 1994 from 3 reaches of the Mesilinka River using either a Surber or basket sampler. Error bars are 1 SE of the mean.

Estimated Fish Abundance, Growth and Size Distribution

Mesilinka and Nation Mainstem

Total fish densities estimated from the underwater counts for the Mesilinka River were 18.1, 38.0 and 27.0 fish ha^{-1} for Blackpine, T1 and T2 respectively. Mountain whitefish dominated in the underwater observations as in previous years (Koning et al. 1995). The higher density of fish in T1 can be attributed to a greater number of mountain whitefish than in either of the other two reaches (Fig. 22). Higher densities of mountain whitefish were recorded from both

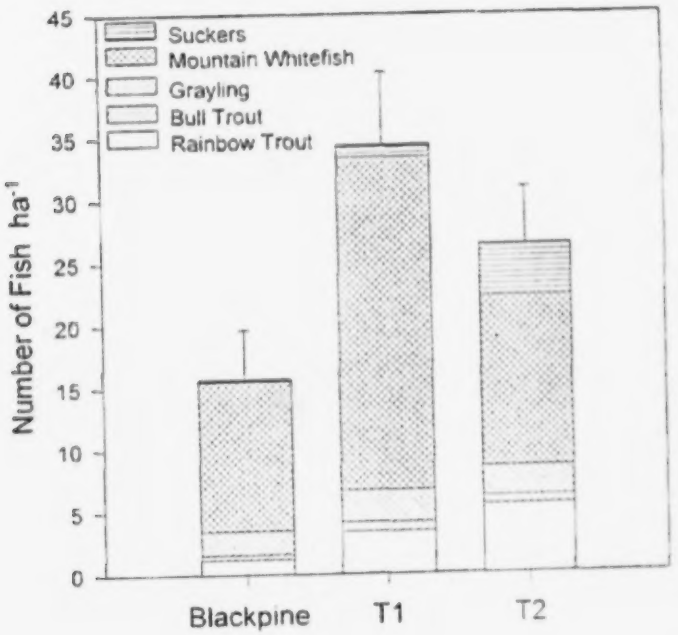

Figure 22 - Density and composition of fishes in the 3 study reaches of the Mesilinka River as estimated from expanded underwater counts. Error bars are 1 SE of the mean from 2 counts.

Blackpine and T1 in 1992 but not 1993 (Koning et al. 1995). Total combined densities of rainbow trout, bull trout and grayling in Blackpine, T1 and T2, respectively, were 4.08, 7.47 and 8.76 fish ha^{-1}. These values are higher for all reaches than 1992 or 1993 values (Koning et al. 1995). Densities of rainbow trout were 2 and 4 fold higher in T1 and T2, respectively, than in the control reach (Fig. 22); however, higher densities of rainbow trout in the treatment reaches are not likely a result of added nutrients as densities in 1992 and 1993 were also 2 and 4 fold

higher than the control reach, albeit absolute numbers were lower (Koning et al. 1995). Densities of arctic grayling and bull trout were similar among the three reaches; while suckers in T2 were 4 and 10 fold higher than T1 and Blackpine respectively (Fig. 22). Estimated arctic grayling densities in Blackpine and T1 were lower than values for 1992 but not 1993 (Koning et al. 1995). Higher densities of suckers in the treatment reaches (especially T2) was also observed in 1992 and 1993 (Koning et al. 1995) and is likely a result of warmer temperatures in the lower river.

Size distributions from the underwater counts indicate that > 66 % of the rainbow trout in all of the reaches are < 30 cm in length (Fig. 23). This figure was greatest in T2 where 87 % of the observed rainbows were < 30 cm in length; although, the largest trout recorded (50-60 cm) was also from T2 (Fig. 23). Relative size distributions for grayling were greater than for rainbow trout with a larger percentage of fish > 30 cm in length. In fact, 100 % of the grayling observed from Blackpine were > 30 cm in length (Fig. 23). However, total densities of grayling were

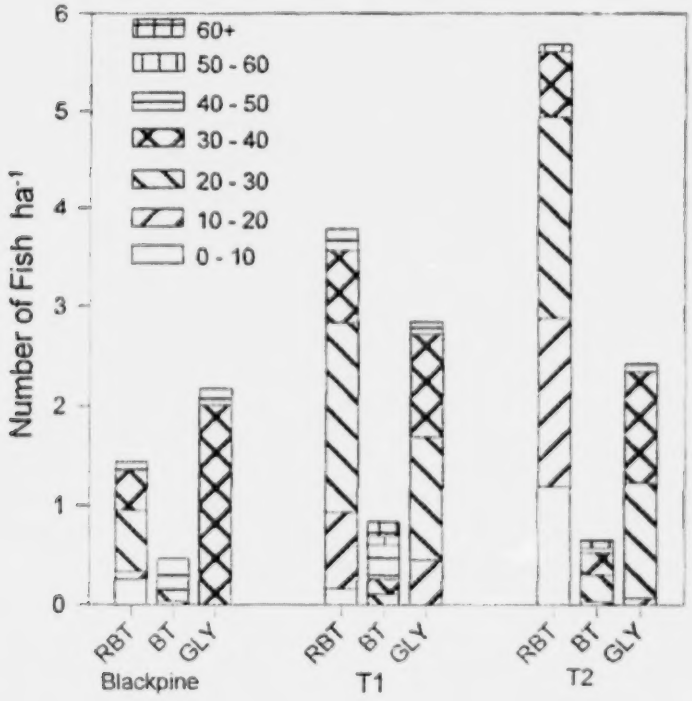

Figure 23 - Density and size distribution (cm) of rainbow trout (RBT), bull trout (BT) and grayling (GLY) from 3 reaches of the Mesilinka River from expanded underwater counts.

lower than for rainbow trout in T1 and T2, but not Blackpine (Fig. 23). Large bull trout were observed from all 3 reaches at low densities (Fig. 23). Finally, a comparison between size

distributions obtained from the underwater counts and from angling indicate that they are in agreement (see Appendix A).

Length (fork length) and weights of rainbow trout between the 3 reaches of the Mesilinka River and Nation River were similar (Fig. 24 and 25) over several age classes. A significant difference in lengths and weights occurred for young-of-year rainbow trout (0+; Table 4), with 0+ rainbows in T1 being significantly larger in length and weight than T2 (Table 4). Although mean length and weight of 0+ rainbows in T1 was much larger than Blackpine, the difference was not significant because of the small sample size (2) of rainbow trout from Blackpine (Table 4). Yearling (1+) rainbows weighed significantly more in T2 than either T1 or Blackpine (Table 4). The mean length of 1+ rainbows in T2 was also greater than the other two reaches; however, the difference was not significant (Table 4). The observed differences in 0+ and 1+ rainbows among reaches of the Mesilinka River can not be attributed to the time samples were taken. All sampling for 0+ and 1+ rainbows occurred by electroshocking during the last week of August 1994 *(see Mesilinka Side-Channels and Tributaries)*. The remaining year classes (2+ - 5+) were not significantly different among the 3 study reaches of the Mesilinka River or the Nation River (Table 4). The similarity in lengths and weights of age 2+ and older fish in the Mesilinka and Nation rivers parallel trends observed in the same rivers during 1993 (Koning et al. 1995). However, during 1992 Koning et al. (1995) noted that on average age 2+ to 4+ rainbow trout weighed substantially more in the Nation River than the Mesilinka River.

Insufficient numbers of grayling were captured to statistically test for differences in lengths or weights among reaches (Table 4). However, average lengths and weights of grayling were greatest in the Nation River followed by the Blackpine reach of the Mesilinka River (Table 3; Fig. 25 and 26). Age-specific lengths and weights of grayling were lowest in T1 and T2 of the Mesilinka River (Table 4; Fig. 26 and 27). Koning et al. (1995) reported that lengths and weights of age 2+ to 4+ grayling for 1992 were greater in the Nation River than in the Mesilinka River, with too few grayling caught in 1993 to allow assessment. Data from 1994 support the observation that 2+ to 4+ grayling are larger in the Nation River; however, the lowest number of arctic grayling (8; Table 4) were caught from the Nation River during 1994.

As previously discussed in the section on benthic invertebrates, the power of a test is an important consideration for any environmental study with the specific objective of determining whether an effect has occurred. To assess whether an effect due to fertilization could be detected in fish size from the Mesilinka River, we developed a power curve (Fig. 28) for age 3+ rainbow trout using different sample sizes (ie., number of fish caught). The resulting surface (Fig. 28) plots the power of the test using a one-way ANOVA with 3 groups (a control and 2 treatment reaches) given a variable response (percent difference) in fish weight from fertilization. We assumed age 3+ fish to weigh approximately 130 g and have a standard deviation of 41 g (Fig. 25) and statistical significance was set at $\alpha = 0.05$.

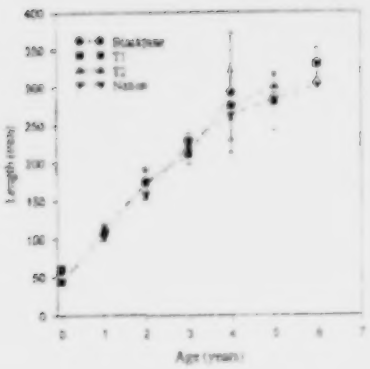

Figure 24 - Length-at-age for rainbow trout from the Mesilinka and Nation rivers. Error bars are 2 standard errors of the mean. Numbers for each point are listed in Table 3.

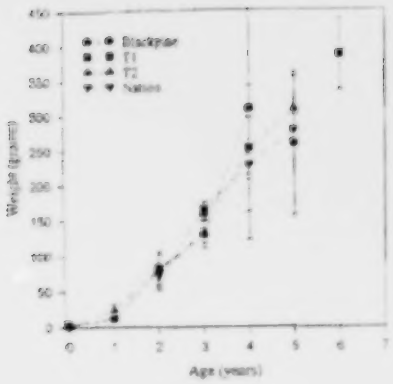

Figure 25 - Weight-at-age for rainbow trout from the Mesilinka and Nation rivers. Error bars are 2 standard errors of the mean. Numbers for each point are listed in Table 3.

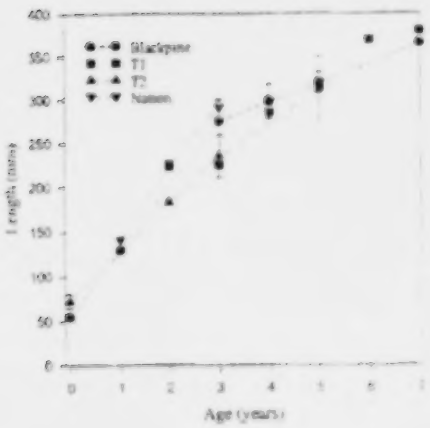

Figure 26 - Length-at-age for Arctic grayling from the Mesilinka and Nation rivers. Error bars are 2 standard errors of the mean. Numbers for each point are listed in Table 3.

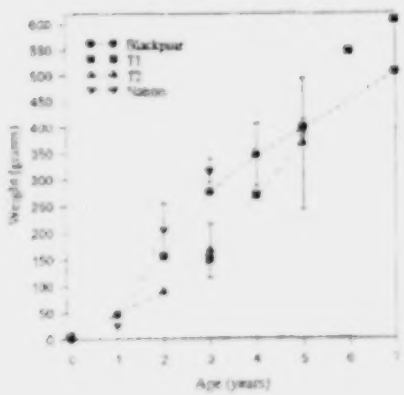

Figure 27 - Weight-at-age for Arctic grayling from the Mesilinka and Nation rivers. Error bars are 2 standard errors of the mean. Numbers for each point are listed in Table 3.

Table 4 - Mean lengths and weights for rainbow trout and grayling aged using scales. Significant differences ($P < 0.05$, tested using ANOVA with Student-Newman-Keuls multiple comparison among means) in lengths or weights for a given age class of rainbow trout are indicated by values with a different letter (e.g., two values with the letter *a* are not significantly different). Arctic grayling were not tested due to their low numbers.

		Rainbow Trout			Arctic Grayling		
		N	Length (mm)	Weight (g)	N	Length (mm)	Weight (g)
0+	Blackpine	2	44.5 ab*	1.1 ab*	1	55	1.2
	T1	8	59.8 a*	2.46 a*	0	–	–
	T2	44	42.7 b*	0.84 b*	5	72.6	7.02
	Nation	0	-	-	0	-	-
1+	Blackpine	10	105.5 a*	12.62 a	1	129	46
	T1	9	108.3 a*	12.52 a	0	-	–
	T2	6	115.2 a*	24.12 b	0	–	–
	Nation	0	-	-	1	141	25
2+	Blackpine	5	175 a*	79.2 a*	0	–	–
	T1	2	173.5 a*	83.5 a*	1	224	156
	T2	9	171.8 a*	81.44 a*	1	183	90
	Nation	44	158.9 a*	72.00 a*	2	227	205
3+	Blackpine	5	209.6 a	130.4 a	1	275	276
	T1	17	228.7 a	160.88 a	2	225.5	151
	T2	25	217.5 a	134.08 a	3	235	166
	Nation	93	226.8 a	165.18 a	5	291.4	316.08
4+	Blackpine	2	292 a	308.5 a	6	298.5	346
	T1	4	274.8 a	252.25 a	3	285.7	269.33
	T2	15	274.7 a	251.67 a	0	–	–
	Nation	64	262.7 a	228.76 a	0	-	-
5+	Blackpine	0	-	-	4	319.5	397
	T1	3	279.7 a	258 a	7	318.3	397.4
	T2	3	300 a	307.67 a	2	312.5 *	368.5
	Nation	15	283.7 a	277.73 a	0	-	–
6+	Blackpine	0	-	–	0	-	–
	T1	2	330.5	386	1	369	546
	T2	0	-	–	0	–	–
	Nation	1	303	n.r.	0		-
7+	Blackpine	0	-	–	1	365	506
	T1	0	–	–	1	379	606
	T2	0	-	–	0	–	-
	Nation	0	-	-	0	-	-

n.r. - not recorded

* - nonparametric test (Kruskal-Wallis and Dunn's comparison) used because assumptions of equal variance or normality were not met

Based on the power curve (Fig. 28), it is unlikely that an increase of 25% in mean weight of age 3+ rainbow trout could be detected as the power is < 50% even at a sample size equal to 70 fish (Fig. 28). However, the power of the test increases sharply as the mean difference between weight rises above 30% (Fig. 28). Studies on juvenile steelhead trout and coho salmon (Oncorhynchus kisutch) from more temperate coastal streams have reported 40-100% increases in mean weights from fertilization (Slaney and Ward 1993). Although, in an arctic tundra system mean weights of adult grayling measured during August were only 3 - 19% greater in the fertilized reach compared to the control reach (Deegan and Peterson 1992). However, the change in weight of adult grayling between fertilized and unfertilized reaches measured over the summer showed a much stronger response (50-140%) to fertilization but only in some years (Deegan and Peterson 1992). We cannot yet predict the magnitude of change in mean weights of fish from the Mesilinka River following fertilization. However, given the power curve tor age 3+ rainbow trout, a small increase (1- 25%) may go undetected; therefore, several factors should be considered. First, fertilization should proceed so as to produce the maximum response in fish populations. If the manipulation is too small or techniques do not allow adequate distribution of both P and N then any effect from fertilization may go undetected in fish populations. Second, sample sizes for fishes (rainbow trout, mountain whitefish and grayling) should be as large as possible (30 fish) to maximize the power of the test. Finally, summer and yearly growth rates of populations and individuals (using tagged fish) will likely provide the most conclusive evidence on the effects of fertilization on fish from the Mesilinka River. Increased effort should be made to estimate growth at the population level (intensive early and late summer sampling) and at the level of the individual (from uniquely tagged fish).

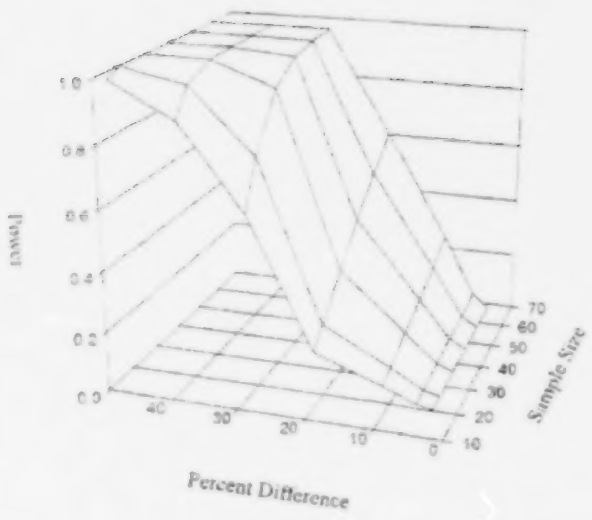

Figure 28 - Power curve for a one-way ANOVA with 3 groups (α=0.05) on age 3+ rainbow trout from the Mesilinka River given a variable response in weight and sample size.

Mesilinka Side-Channels and Tributaries

Rainbow trout dominated catches of juvenile fish from side channels and river margins in all 3 reaches of the Mesilinka (Fig. 29). Only in T2 did juvenile bull trout equal the catch of

rainbow trout (Fig. 29). Catches of juvenile bull trout were low from T1 and absent from Blackpine (Fig. 29). Juvenile grayling were captured from all 3 reaches (Fig. 29) and from similar habitats in each reach. Juvenile Arctic grayling were captured from shallow riffle regions 5-10 cm deep with pebble and cobble substrate (data on file). Only 1 juvenile grayling was caught in a pool habitat (data on file). Longnose dace, mountain whitefish, burbot and sculpins comprised the remainder of the catch from the side channels and river margins. Combined catches of dace, mountain whitefish and burbot never equalled the catch of rainbow trout in any of the reaches (Fig. 29). Sculpins were abundant in the all the reaches (data on file); catches of sculpins were omitted from Figure 29 due to their abundance.

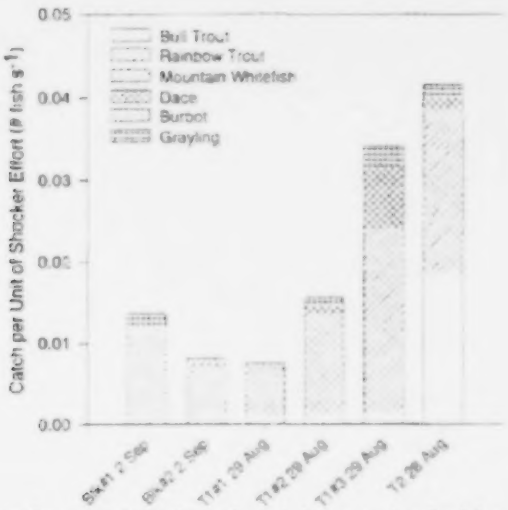

Figure 29 - Electroshocking catches from side channels and river margins for 2 locations in Blackpine (Blk), 3 locations in T1 and one in T2.

Bull trout accounted for the largest proportion of captured juveniles in Culvert, Control and Gopherhole creeks (Fig. 30). Bull trout were most abundant in catches from Control Creek (Fig. 30), which is consistent with past years (Koning et al. 1995). Fatfish Creek was dominated by juvenile rainbows, while Carina Creek had a mixed assemblage of rainbows, suckers and unidentified cyprinids (Fig. 30). Grayling were not found in any of the 5 tributaries. Mountain whitefish were captured from all the tributaries except Carina. Catches of juvenile mountain whitefish never accounted for more than 24 % of the total catch (Fig. 30).

Mark/recapture density estimates of juvenile rainbow trout, bull trout and mountain whitefish combined were greater in Gopherhole and Culvert creeks than in Control Creek (Table 5). The short main channel length shocked in Gopherhole Creek (56 m) was due to an unstable bridge that blocked part of the suitable shocking channel.

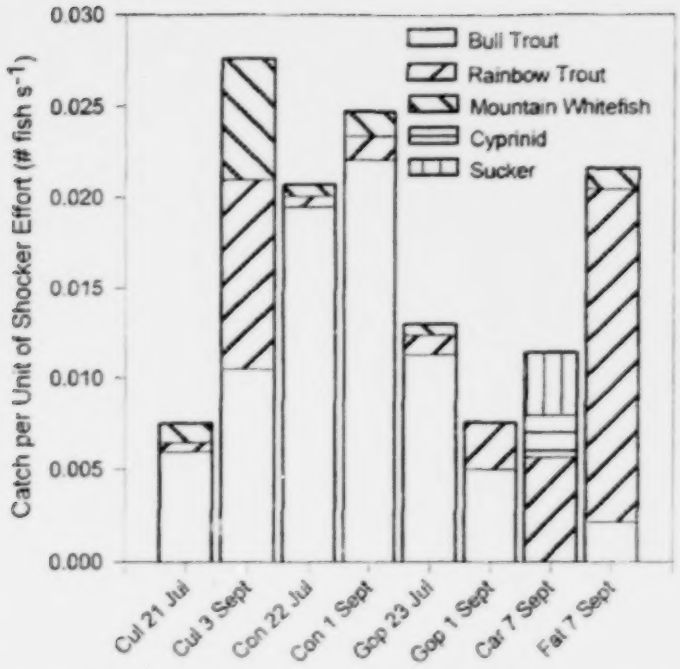

Figure 30 - Electroshocking catches from Culvert (Cul), Control (Con), Gopherhole (Gop), Carina (Car) and Fatfish (Fat). Dates electroshocking took place are indicated.

Table 5 - Mark/recapture combined density estimates of rainbow trout, bull trout and mountain whitefish for 3 tributaries of the Mesilinka River. *95%* binomial confidence intervals (C.I.) are indicated. M indicates number initally marked, C the number captured on the second pass and R the number of recaptures in the second pass.

Tributary	M	C	R	length shocked (m)	mean width (m)	fish density($\#\cdot m^{-2}$ ± *95%* C.I.)
Culvert Ck.	42	21	5	172.6	7.14	0.127 (.075 - .373)
Control Ck.	18	10	3	139	5.16	0.071 (.040 - .293)
Gopherhole Ck.	6	8	1	56 (20.5*)	6.13 (1.4*)	0.083 (.035 - 1.398)

*- length and mean width of a side channel shocked in Gopherhole Creek and included in overall area.

Electroshocking catch-per-unit-effort (CPUE) and mark/recapture density estimates do not show similar trends (Table 5 and Fig. 30). The highest CPUE was for Culvert and Control creeks for early September (Fig. 30); whereas, Control Creek showed the lowest fish densities (rainbow trout, bull trout and mountain whitefish only) for the same period (Table 5). The difference may be a result of different capture efficiencies among the tributaries. However, given the low number of recaptures, and large confidence intervals, for Gopherhole and Culvert creeks, the population estimates are not reliable. Mark/recapture estimates should be conducted from longer reaches in each of Culvert, Control and Gopherhole creeks in future years. Clearing and removal of some brush and deadfall from these tributaries would be required to electroshock longer sections safely.

Results from sampling in 1994 indicate differences in rearing habitats for juvenile rainbow trout, bull trout and grayling. Rainbow trout predominate in side channels and river margins of the mainstem Mesilinka but are also present in the tributaries, especially Fatfish, Culvert and Carina creeks. Bull trout dominate catches in three of the tributaries but are also found in side channels of the lower mainstem, especially T2. Grayling were never captured in any of the tributaries in 1994. However, in 1992 three juvenile grayling were captured in Carina Creek and in 1993 two were captured in Culvert Creek and one in Control Creek. These observations need to be further substantiated by more extensive electro-shocking between reaches and from additional tributaries. Locations of captured fish, along with temperature (and other clearly defined environmental variables), should be recorded to facilitate the distribution of species with their environment. Multivariate statistics (e.g. canonical correspondence analysis) are the appropriate exploratory techniques that should be used on this data. Locations and environmental variables for angled fish should also be recorded if possible. Global positioning systems (GPS) may be a useful tool and should be investigated for practicality and usefulness in future years. However, the use of spatially referenced databases requires careful planning and clear objectives before implementation.

Stable Isotope Analysis

The $\delta^{15}N$ values within biotic and abiotic groups were relatively consistent along the transect stretching from above the first fertilizer station to 15 km below the second fertilizer station (Fig. 31). A slight decline in $\delta^{15}N$ occurs from 2 km upstream of the first fertilizer station to the other sampling sites (Fig. 31) which is consistent the negative fractionation of ^{15}N following fertilization that was observed by Peterson et al. (1993b). However, the decrease in $\delta^{15}N$ values on the Mesilinka River first occurred in the control reach above the fertilizer stations and can not be attributed to fertilization (Fig. 31). The stable $^{\delta15}N$ values from the Mesilinka River indicate that the level of N fertilizer being added is insufficient to stimulate a negative N isotope fractionation which could be used to trace fertilizers through the food web (Peterson, B., pers, comm., The Ecosystem Center, Woods Hole, Massachusetts). Higher levels of ammonium-N ($\approx 50\ \mu g\ L^{-1}$), which shows strong fractionation during algal uptake (Peterson et al. 1993b), or

spiking the fertilizer with enriched ^{15}N are required to enable tracing the pathway of added nutrients using stable isotopes (Peterson, B., pers. comm.).

The $\delta^{13}C$ values mostly lie in between -30 and -25 with no differentiation between terrestrial vegetation and stream algae (Fig. 32). Because $\delta^{13}C$ fall within 5 - 6 of each other, terrestrial versus stream sources of C can not be distinguished among organisms. Although $\delta^{13}C$ values have been used to trace C sources in some aquatic systems (Fry and Sherr 1984), its utility in tracing C pathways in stream ecosystems has been questioned (France 1995). The variability observed in $\delta^{13}C$ values for attached algae often envelopes terrestrial $\delta^{13}C$ values, thereby, obscuring any discrete differences between the two sources that can be traced through the food

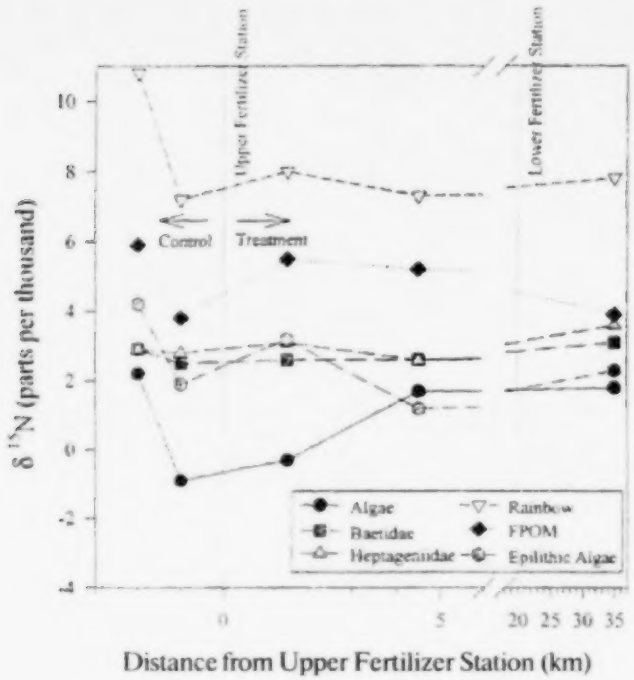

Figure 31 - The $\delta^{15}N$ values for 5 biotic groups and fine particulate organic matter (FPOM).

web (France 1995). These conclusions are supported by our results, in which the $\delta^{13}C$ values for algae lie between the bounds of the values recorded for terrestrial vegetation (Fig. 32). Although variable, $\delta^{13}C$ values in biotic and abiotic groupings did not show any observable trends along

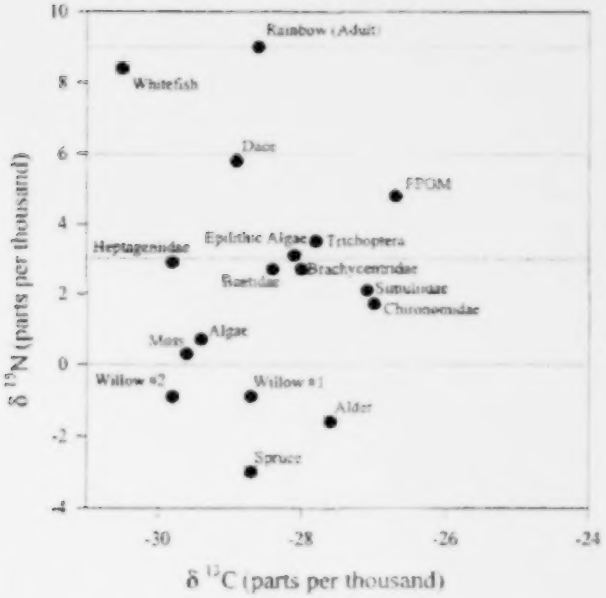

Figure 32 - Stable isotope diagram for the Mesilinka River including terrestrial vegetation. Values represent averages from the 2 pre-fertilization sites. Lines are at 3 ppt intervals.

the fertilization transect.

$\delta^{15}N$ values for Mesilinka River illustrate the relative trophic position of the sampled organisms in the food web (Fig. 32). Approximately, a 3 part per thousand increase in $\delta^{15}N$ occurs at each trophic level with rainbow trout and whitefish occupying the role of top consumer from the organisms sampled (Fig. 32). Bull trout were not sampled; however, it is hypothesized that large river resident bull trout would have a $\delta^{15}N$ of up to 12 parts per thousand (Peterson, B., pers. comm.). Furthermore, invertebrate predators (e.g., Plecopterans) which feed on grazing insects were not sampled and would likely have a $\delta^{15}N$ similar to dace ($\approx$ 6 parts per thousand). This would explain the trophic position of mountain whitefish (Fig. 32) which are unlikely to be

piscivorous. Finally, because terrestrial versus stream sources of C are not discernable, the importance of terrestrial insects in the diets of rainbow trout and whitefish can not be ruled out.

CONCLUSIONS

Fertilizer addition to the Mesilinka River produced an increases in periphyton and benthic invertebrate biomass when compared to reference areas. Furthermore, periphyton and invertebrate biomass was greater in the two fertilized reaches in 1994 than in 1993 (no fertilizer addition). However, the difference in benthic invertebrate biomass between years was not statistically significant, likely a result of the variability associated with the invertebrate samples and subsequent low power of statistical tests performed. In future years, the number of benthic baskets, used to sample invertebrates, should be increased from 10 to 20 thereby increasing the statistical tests power to an acceptable level. The effective distance of fertilization downstream should also be investigated further in the future by placing a series of periphyton blocks downstream from the fertilizer stations. Finally, to prevent N limitation at the lower fertilizer station urea-ammonium nitrate should also be added at this station in similar concentrations to the upper fertilizer station (Roadend).

No difference was observed in the abundance or size-at-age of fish in the Mesilinka River following fertilization. Given that the only organisms that responded to fertilization in this first year were a producer (algae; Fig. 32) and primary consumer (Chironomidae; Fig. 32), it may be expected that fish, which (as adults) are likely three trophic levels above periphyton, may take several years to respond to fertilization. Sufficient effort should be given to sampling fish so that any biological response can be clearly distinguished given the known variability associated with the system. Specifically, sample sizes to determine size-at-age statistics should be 30 fish for each species and age class. Recruitment of juvenile salmonids into the adult stock is relatively unknown for the Mesilinka River and requires more intensive study. In particular, quantification of juvenile salmonid densities in side channels of the Mesilinka River should be conducted. Juvenile salmonids (e.g., < 100 mm) are prevalent in side channels of the Mesilinka River (Appendix B); and therefore, may be directly affected by mainstem fertilization.

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Appendices

Appendix A - Length-frequency plots for rainbow trout, Arctic grayling and bull trout captured by angling from the control reach (Blackpine) and the two treatment reaches (T1 and T2) of the Mesilinka River. Frequencies are shown as a relative percent of the total catch from a given reach.

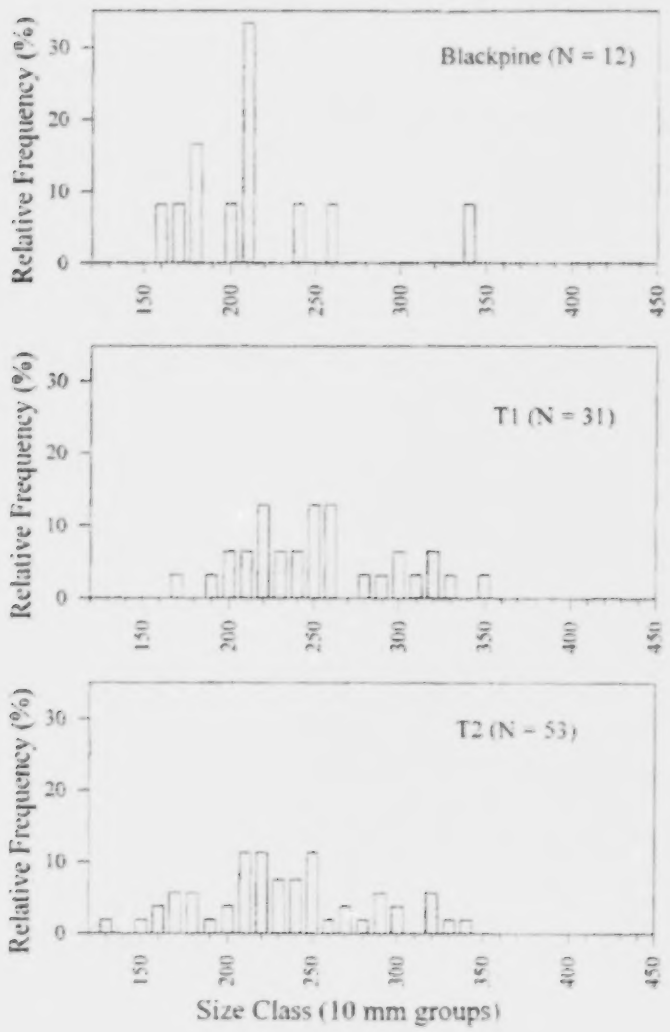

Figure A1 - Length-frequency plots for rainbow trout from the Mesilinka River.

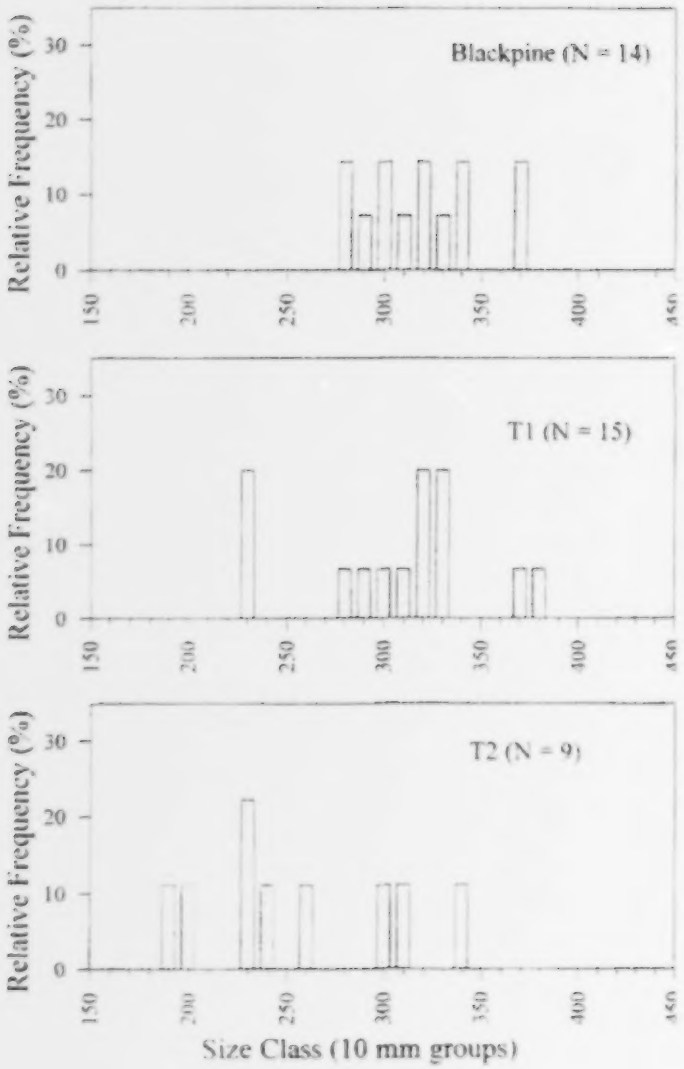

Figure A2 - Length-frequency plots for Arctic grayling from the Mesilinka River.

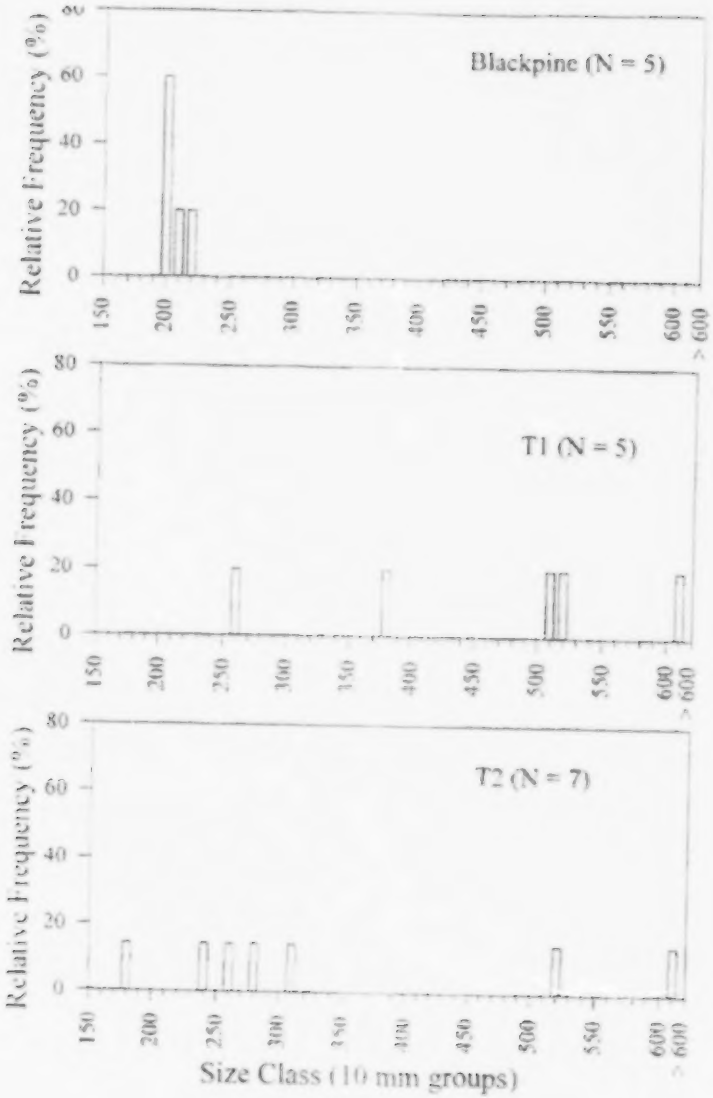

Figure A3 - Length-frequency plots for bull trout in the Mesilinka River.

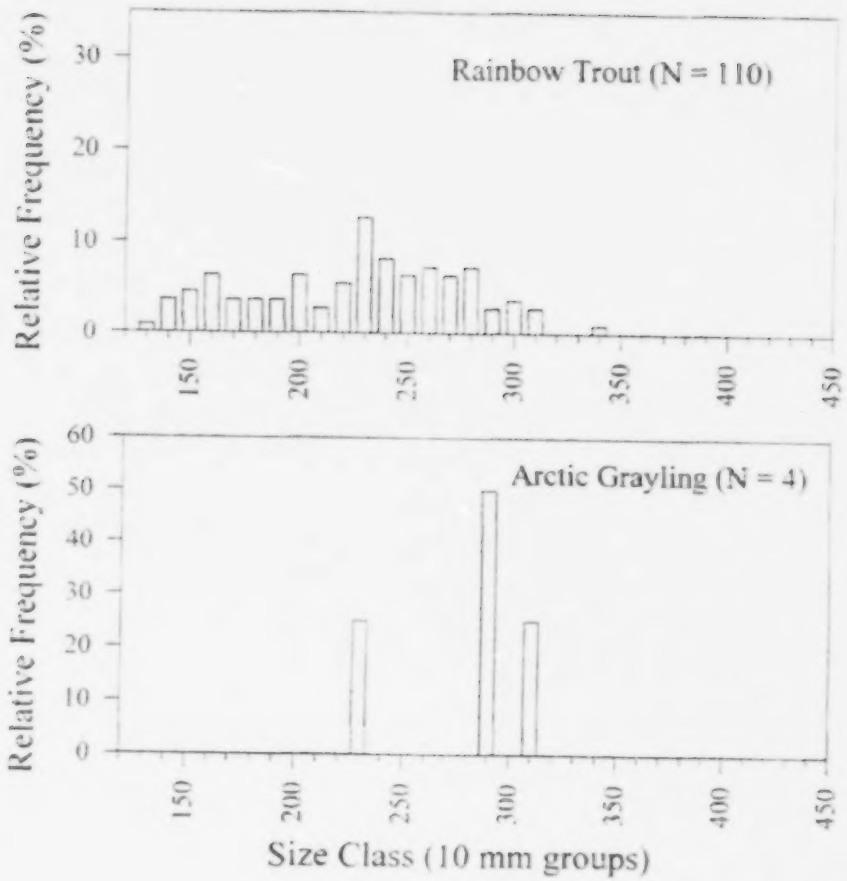

Figure A4 - Length-frequency plots for the Nation River.

Appendix B - Record of fish caught from the three study reaches of the Mesilinka River (Blackpine, T1 and T2) and the 5 tributaries (Carina, Control, Culvert, Fatfish and Gopherhole) by angling or electrofishing. The table is arranged in alphabetical order based on location then species.

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grains)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag #[4]
BLACKPINE	BUR			02-Sep-94	135	12.6		0		
BLACKPINE	DACE			02-Sep-94	35	0.5		0		
BLACKPINE	BT			03-Aug-94	202	94		0		
BLACKPINE	BT			03-Aug-94	192	88		0		
BLACKPINE	BT			03-Aug-94	196	94		0		
BLACKPINE	BT			07-Aug-94	192	77		0		
BLACKPINE	BT	GR	4063	07-Aug-94	212	104		0		
BLACKPINE	GLY			03-Aug-94	129	46	1+	0		
BLACKPINE	GLY			03-Aug-94	365	556		0		
BLACKPINE	GLY			02-Sep-94	44	0.6		0		
BLACKPINE	GLY			02-Sep-94	55	1.2	0+	0		
BLACKPINE	GLY	BL	1	30-Jun-94	335	400	5+	0		
BLACKPINE	GLY	GR	4061	03-Aug-94	333	456	4+	0		
BLACKPINE	GLY	GR	4052	03-Aug-94	319	401	4+	0		
BLACKPINE	GLY	GR	4052	07-Aug-94				1	GR	4052
BLACKPINE	GLY	GR	4053	03-Aug-94	295	316	4+	0		
BLACKPINE	GLY	GR	4054	03-Aug-94	281	301	4+	0		
BLACKPINE	GLY	GR	4057	03-Aug-94	275	276	3+	0		
BLACKPINE	GLY	GR	4058	03-Aug-94	291	346	4+	0		
BLACKPINE	GLY	GR	4059	03-Aug-94	272	256	4+	0		
BLACKPINE	GLY	GR	4059	07-Aug-94				1	GR	4059
BLACKPINE	GLY	GR	4062	03-Aug-94	308	381	5+	0		
BLACKPINE	GLY	GR	4064	07-Aug-94	365	506	7+	0		
BLACKPINE	GLY	GR	4068	07-Aug-94	321	406	5+	0		
BLACKPINE	GLY	PK	27	03-Aug-94	314	401	5+	1	PK	27
BLACKPINE	MWF			02-Sep-94	53	1.3		0		
BLACKPINE	MWF			02-Sep-94	64	2.3	0+	0		
BLACKPINE	MWF	GR	4060	03-Aug-94	245	186	5+	0		
BLACKPINE	RBT			30-Jun-94	156	42	2+	0		
BLACKPINE	RBT			03-Aug-94	175	78	2+	0		
BLACKPINE	RBT			03-Aug-94	332	401	4+	0		
BLACKPINE	RBT			03-Aug-94	174	80	2+	0		
BLACKPINE	RBT			03-Aug-94	165	70	2+	0		
BLACKPINE	RBT			03-Aug-94	204	126	3+	0		
BLACKPINE	RBT			02-Sep-94	111	15.5	1+	0		
BLACKPINE	RBT			02-Sep-94	94	8.7	1+	0		
BLACKPINE	RBT			02-Sep-94	112	15.6	1+	0		
BLACKPINE	RBT			02-Sep-94	44	0.8		0		
BLACKPINE	RBT			02-Sep-94	49	1.3		0		
BLACKPINE	RBT			02-Sep-94	45	1.2	0+	0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag #[4]
BLACKPINE	RBT			02-Sep-94	104	13.3	1+	0		
BLACKPINE	RBT			02-Sep-94	37	0.6		0		
BLACKPINE	RBT			02-Sep-94	120	17.1	1+	0		
BLACKPINE	RBT			02-Sep-94	43	0.7		0		
BLACKPINE	RBT			02-Sep-94	37	0.6		0		
BLACKPINE	RBT			02-Sep-94	107	12.3	1+	0		
BLACKPINE	RBT			02-Sep-94	44	1.3		0		
BLACKPINE	RBT			02-Sep-94	46	1.2		0		
BLACKPINE	RBT			02-Sep-94	86	6.3	1+	0		
BLACKPINE	RBT			02-Sep-94	44	1	0+	0		
BLACKPINE	RBT			02-Sep-94	47	1.1		0		
BLACKPINE	RBT			02-Sep-94	44	0.9		0		
BLACKPINE	RBT			02-Sep-94	53	1.5		0		
BLACKPINE	RBT			02-Sep-94	41	0.7		0		
BLACKPINE	RBT			02-Sep-94	49	1.4		0		
BLACKPINE	RBT			02-Sep-94	91	8.3	1+	0		
BLACKPINE	RBT			02-Sep-94	113	14.4	1+	0		
BLACKPINE	RBT			02-Sep-94	117	14.7	1+	0		
BLACKPINE	RBT			02-Sep-94	47	1		0		
BLACKPINE	RBT			02-Sep-94	54	1.6		0		
BLACKPINE	RBT	GR	4055	03-Aug-94	252	216	4+	0		
BLACKPINE	RBT	GR	4056	03-Aug-94	205	126	2+	0		
BLACKPINE	RBT	GR	4061	03-Aug-94	200	116	3+	0		
BLACKPINE	RBT	GR	4065	07-Aug-94	202	114	3+	0		
BLACKPINE	RBT	GR	4066	07-Aug-94	232	166	3+	0		
BLACKPINE	RBT	GR	4067	07-Aug-94	210	130	3+	0		
CARINA	CYP			07-Sep-94	48	0.9		0		
CARINA	CYP			07-Sep-94	42	0.7		0		
CARINA	RBT			07-Sep-94	59	2.4	0+	0		
CARINA	RBT			07-Sep-94	60	2.3	0+	0		
CARINA	RBT			07-Sep-94	54	1.8	0+	0		
CARINA	RBT			07-Sep-94	51	1	0+	0		
CARINA	RBT	BL	45	07-Sep-94	234	128.5	3+	0		
CARINA	SUCK			07-Sep-94	44	0.6		0		
CARINA	SUCK			07-Sep-94	184	83.6		0		
CARINA	SUCK			07-Sep-94	113	17.7		0		
CONTROL	BT			22-Jul-94	34			0		
CONTROL	BT			22-Jul-94	35			0		
CONTROL	BT			22-Jul-94	38			0		
CONTROL	BT			22-Jul-94	64	5		0		
CONTROL	BT			22-Jui-94	66	4		0		
CONTROL	BT			22-Jul-94	33	0.5		0		
CONTROL	BT			22-Jul-94	68	5.5		0		
CONTROL	BT			22-Jul-94	66	5		0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag #[4]
CONTROL	BT			22-Jul-94	33			0		
CONTROL	BT			22-Jul-94	100	12	1+	0		
CONTROL	BT			22-Jul-94	27			0		
CONTROL	BT			22-Jul-94	27			0		
CONTROL	BT			22-Jul-94	29			0		
CONTROL	BT			22-Jul-94	59	2.5		0		
CONTROL	BT			22-Jul-94	70	5.5		0		
CONTROL	BT			22-Jul-94	31			0		
CONTROL	BT			22-Jul-94	29			0		
CONTROL	BT			22-Jul-94	32			0		
CONTROL	BT			22-Jul-94	37			0		
CONTROL	BT			22-Jul-94	34			0		
CONTROL	BT			22-Jul-94	60	4		0		
CONTROL	BT			22-Jul-94	35			0		
CONTROL	BT			22-Jul-94	30			0		
CONTROL	BT			22-Jul-94	34			0		
CONTROL	BT			22-Jul-94	25			0		
CONTROL	BT			22-Jul-94	25			0		
CONTROL	BT			22-Jul-94	61	5	0+	0		
CONTROL	BT			22-Jul-94	31			0		
CONTROL	BT			22-Jul-94	67	4	0+	0		
CONTROL	BT			22-Jul-94	32			0		
CONTROL	BT			22-Jul-94	36			0		
CONTROL	BT			22-Jul-94	31			0		
CONTROL	BT			22-Jul-94	34			0		
CONTROL	BT			01-Sep-94	39	0.7		0		
CONTROL	BT			01-Sep-94	38	0.6		0		
CONTROL	BT			01-Sep-94	79	5.4		0		
CONTROL	BT			01-Sep-94	41	0.7		0		
CONTROL	BT			01-Sep-94	42	1.1		0		
CONTROL	BT			01-Sep-94	42	0.7		0		
CONTROL	BT			01-Sep-94	108	12.8		0		
CONTROL	BT	UC		01-Sep-94	48			0		
CONTROL	BT	UC		01-Sep-94	41			0		
CONTROL	BT	UC		01-Sep-94	35			0		
CONTROL	BT	UC		01-Sep-94	47	1		0		
CONTROL	BT	UC		01-Sep-94	44			0		
CONTROL	BT			01 Sep-94	45			0		
CONTROL	BT	UC		01-Sep-94	44			0		
CONTROL	BT	UC		01-Sep-94	44			0		
CONTROL	BT	UC		01-Sep-94	44			0		
CONTROL	BT	UC		01-Sep-94	86			0		
CONTROL	BT	UC		01-Sep-94	44			0		
CONTROL	BT	UC		01-Sep-94	67	3.6		1	UC	

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag#[4]
CONTROL	BT	UC		01-Sep-94	43			0		
CONTROL	BT	UC		01-Sep-94	136			0		
CONTROL	BT	UC		01-Sep-94	42			0		
CONTROL	BT	UC		01-Sep-94	47			0		
CONTROL	BT	UC		01-Sep-94	134	33		1	UC	
CONTROL	BT	UC		01-Sep-94	135			0		
CONTROL	BT	UC		01-Sep-94	68			0		
CONTROL	MWF			22-Jul-94	155	42.5	n/s	0		
CONTROL	MWF	UC		01-Sep-94	122			0		
CONTROL	RBT			22-Jul-94	88	9.5	n/s	0		
CONTROL	RBT	UC		01-Sep-94	154			0		
CONTROL	RBT	UC		01-Sep-94	152	41.5	2+	1	UC	
CULVERT	BT			21-Jul-94	130	28	n/s	0		
CULVERT	BT			21-Jul-94	93	10	n/s	0		
CULVERT	BT			21-Jul-94	71	5	n/s	0		
CULVERT	BT			21-Jul-94	146	33	n/s	0		
CULVERT	BT			21-Jul-94	85	9	n/s	0		
CULVERT	BT			21-Jul-94	75	8	n/s	0		
CULVERT	BT			21-Jul-94	90	11	n/s	0		
CULVERT	BT			21-Jul-94	31			0		
CULVERT	BT			21-Jul-94	30			0		
CULVERT	BT			21-Jul-94	36			0		
CULVERT	BT			21-Jul-94	32			0		
CULVERT	BT			21-Jul-94	30			0		
CULVERT	BT			03-Sep-94	75	4.6		0		
CULVERT	BT			03-Sep-94	49	1		0		
CULVERT	BT			03-Sep-94	123	16.9		0		
CULVERT	BT			03-Sep-94	51	1.2		0		
CULVERT	BT			03-Sep-94	45	0.8		0		
CULVERT	BT			03-Sep-94	77	4.9		0		
CULVERT	BT	BL	44	03-Sep-94	335			1	BL	44
CULVERT	BT	BL	44	03-Sep-94	335			0		
CULVERT	BT	DC		03-Sep-94	56			0		
CULVERT	BT	DC		03-Sep-94	88			0		
CULVERT	BT	DC		03-Sep-94	152			0		
CULVERT	BT	DC		03-Sep-94	119			0		
CULVERT	BT	DC		03-Sep-94	112			0		
CULVERT	BT	DC		03-Sep-94	47			0		
CULVERT	BT	DC		03-Sep-94	41			0		
CULVERT	BT	DC		03-Sep-94	40			0		
CULVERT	BT	DC		03-Sep-94	46			0		
CULVERT	BT	DC		03-Sep-94	42			0		
CULVERT	BT	DC		03-Sep-94	45			0		
CULVERT	BT	DC		03-Sep-94	42			0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag#[4]
CULVERT	BT	DC		03-Sep-94	46			0		
CULVERT	BT	DC		03-Sep-94	49			0		
CULVERT	BT	DC		03-Sep-94	45			0		
CULVERT	MWF			03-Sep-04	78	3.5	0+	0		
CULVERT	MWF			21-Jul-94	95	9	1+	0		
CULVERT	MWF			21-Jul-94	105	10	1+	0		
CULVERT	MWF			03-Sep-94	79	4.3	0+	0		
CULVERT	MWF			03-Sep-94	77	3.3	0+	0		
CULVERT	MWF			03-Sep-94	83	4.2	0+	0		
CULVERT	MWF	DC		03-Sep-94	80			0		
CULVERT	MWF	DC		03-Sep-94	77			0		
CULVERT	MWF	DC		03-Sep-94	74			0		
CULVERT	MWF	DC		03-Sep-94	80			0		
CULVERT	MWF	DC		03-Sep-94	66			0		
CULVERT	MWF	DC		03-Sep-94	83			0		
CULVERT	MWF	DC		03-Sep-94	82			0		
CULVERT	MWF	DC		03-Sep-94	73			0		
CULVERT	RBT			21-Jul-94	81	8	1+	0		
CULVERT	RBT			03-Sep-94	54	1.9	0+	0		
CULVERT	RBT			03-Sep-94	48	1		0		
CULVERT	RBT			03-Sep-94	47	1.1		0		
CULVERT	RBT			03-Sep-94	50	1.4		0		
CULVERT	RBT	DC		03-Sep-94	52			0		
CULVERT	RBT	DC		03-Sep-94	81	6.3	1+	1	DC	
CULVERT	RBT	DC		03-Sep-94	57			0		
CULVERT	RBT	DC		03-Sep-94	95			0		
CULVERT	RBT	DC		03-Sep-94	91	9.2	1+	1	DC	
CULVERT	RBT	DC		03-Sep-94	56	3.1	0+	1	DC	
CULVERT	RBT	DC		03-Sep-94	50			0		
CULVERT	RBT	DC		03-Sep-94	55			0		
CULVERT	RBT	DC		03-Sep-94	81			0		
CULVERT	RBT	DC		03-Sep-94	51			0		
CULVERT	RBT	DC		03-Sep-94	52			0		
CULVERT	RBT	DC		03-Sep-94	53			0		
CULVERT	RBT	DC		03-Sep-94	59			0		
CULVERT	RBT	DC		03-Sep-94	50			0		
CULVERT	RBT	DC		03-Sep-94	50			0		
CULVERT	RBT	DC		03-Sep-94	54			0		
CULVERT	RBT	DC		03-Sep-94	49			0		
CULVERT	RBT	DC		03-Sep-94	46			0		
CULVERT	RBT	DC		03-Sep-94	45			0		
CULVERT	RBT	DC		03-Sep-94	50	1.4		1	DC	
CULVERT	RMW	DC		03-Sep-94	68			0		
CULVERT	SCL			21-Jul-94	80	9		0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag#[4]
CULVERT	SCL			21-Jul-94	53	2		0		
CULVERT	SCL			21-Jul-94	64	4		0		
CULVERT	SCL			21-Jul-94	77	7		0		
CULVERT	SCL			21-Jul-94	76	7		0		
CULVERT	SCL			21-Jul-94	90	10.5		0		
CULVERT	SCL			21-Jul-94	69	4		0		
CULVERT	SCL			21-Jul-94	70	5		0		
CULVERT	SCL			21-Jul-94	75	6		0		
CULVERT	SCL			21-Jul-94	69	5		0		
CULVERT	SCL			21-Jul-94	69	6		0		
CULVERT	SCL			21-Jul-94	76	5.5		0		
CULVERT	SCL			21-Jul-94	73	5		0		
CULVERT	SCL			21-Jul-94	80	6		0		
CULVERT	SCL			21-Jul-94	66	5		0		
CULVERT	SCL			21-Jul-94	81	9		0		
CULVERT	SCL			21-Jul-94	80	7		0		
CULVERT	SCL			21-Jul-94	67	4		0		
CULVERT	SCL			21-Jul-94	80	8		0		
CULVERT	SCL			21-Jul-94	67	5		0		
CULVERT	SCL			21-Jul-94	65	4		0		
CULVERT	SCL			21-Jul-94	70	5		0		
CULVERT	SCL			21-Jul-94	66	3		0		
CULVERT	SCL			21-Jul-94	56	4		0		
CULVERT	SCL			21-Jul-94	80	7		0		
CULVERT	SCL			21-Jul-94	77	7		0		
CULVERT	SCL			21-Jul-94	72	6		0		
CULVERT	SCL			21-Jul-94	68	5		0		
CULVERT	SCL			21-Jul-94	68	5		0		
FATFISH	BT			07-Sep-94	189	70.5		0		
FATFISH	BT			07-Sep-94	147	23		0		
FATFISH	MWF			07-Sep-94	84	5.1	0+	0		
FATFISH	RBT			07-Sep-94	44	0.9		0		
FATFISH	RBT			07-Sep-94	45	0.7		0		
FATFISH	RBT			07-Sep-94	47	0.8		0		
FATFISH	RBT			07-Sep-94	44	1.2		0		
FATFISH	RBT			07-Sep-94	35	0.5		0		
FATFISH	RBT			07-Sep-94	51	1.4		0		
FATFISH	RBT			07-Sep-94	81	6.6	1+	0		
FATFISH	RBT			07-Sep-94	39	0.7		0		
FATFISH	RBT			07-Sep-94	48	0.7		0		
FATFISH	RBT			07-Sep-94	89	18.9	1+	0		
FATFISH	RBT			07-Sep-94	56	1.4	0+	0		
FATFISH	RBT			07-Sep-94	48	1.4		0		
FATFISH	RBT			07-Sep-94	94	8	1+	0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag#	Date	Len. (mm)	Weight (grains)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag #[4]
FATFISH	RBT			07-Sep-94	45	1.1		0		
FATFISH	RBT			07-Sep-94	44	1		0		
FATFISH	RBT			07-Sep-94	37	0.5		0		
FATFISH	RBT			07-Sep-94	39	0.6		0		
GOPHERHOLE	BT			23-Jul-94	85	7.5	1+	0		
GOPHERHOLE	BT			23-Jul-94	35			0		
GOPHERHOLE	BT			23-Jul-94	88	9	1+	0		
GOPHERHOLE	BT			23-Jul-94	64	4	0+	0		
GOPHERHOLE	BT			23-Jul-94	31			0		
GOPHERHOLE	BT			23-Jul-94	89	8	1+	0		
GOPHERHOLE	BT			23-Jul-94	92	7	1+	0		
GOPHERHOLE	BT			23-Jul-94	89	10	1+	0		
GOPHERHOLE	BT			23-Jul-94	103	12	1+	0		
GOPHERHOLE	BT			23-Jul-94	35			0		
GOPHERHOLE	BT			23-Jul-94	79	7	1+	0		
GOPHERHOLE	BT			23-Jul-94	31			0		
GOPHERHOLE	BT			23-Jul-94	33			0		
GOPHERHOLE	BT			23-Jul-94	30			0		
GOPHERHOLE	BT			23-Jul-94	33			0		
GOPHERHOLE	BT			23-Jul-94	100	10	1+	0		
GOPHERHOLE	BT			23-Jul-94	91	8	1+	0		
GOPHERHOLE	BT			23-Jul-94	33			0		
GOPHERHOLE	BT			23-Jul-94	93	10.5	1+	0		
GOPHERHOLE	BT			23-Jul-94	31			0		
GOPHERHOLE	BT			01-Sep-94	45	1.2		0		
GOPHERHOLE	BT			01-Sep-94	87	6.8		0		
GOPHERHOLE	BT			01-Sep-94	34	0.5		0		
GOPHERHOLE	BT			01-Sep-94	46	1.1		0		
GOPHERHOLE	BT			01-Sep-94	75	4.1		0		
GOPHERHOLE	BT			01-Sep-94	101	10.9		0		
GOPHERHOLE	BT	LC		01-Sep-94	52			0		
GOPHERHOLE	BT	LC		01-Sep-94	55			0		
GOPHERHOLE	BT	LC		01-Sep-94	95	10.2		1	LC	
GOPHERHOLE	BT	LC		01-Sep-94	49			0		
GOPHERHOLE	BT	LC		01-Sep-94	83			0		
GOPHERHOLE	BT	LC		01-Sep-94	101			0		
GOPHERHOLE	BT	LC		01-Sep-94	83			0		
GOPHERHOLE	MWF			23-Jul-94	218	136	n/s	0		
GOPHERHOLE	RBT			23-Jul-94	153	47.5	n/s	0		
GOPHERHOLE	RBT			23-Jul-94	53	4	0+	0		
GOPHERHOLE	RBT			01-Sep-94	76	5	0+	0		
GOPHERHOLE	SCL			23-Jul-04	57	3		0		
GOPHERHOLE	SCL			23-Jul-94	41	2		0		
GOPHERHOLE	SCL			23-Jul-94	23			0		

Location	Species'	Floy Tag Color	Floy Tag#	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag#[4]
GOPHERHOLE	SCL			23-Jul-94	61	5.5		0		
GOPHERHOLE	SCL			23-Jul-94	71	7.5		0		
GOPHERHOLE	SCL			23-Jul-94	38	0.5		0		
GOPHERHOLE	SCL			23-Jul-94	39	2.5		0		
GOPHERHOLE	SCL			23-Jul-94	62	4		0		
GOPHERHOLE	SCL			23-Jul-94	56	3		0		
GOPHERHOLE	SCL			23-Jul-94	59	3		0		
GOPHERHOLE	SCL			23-Jul-94	79	9		0		
GOPHERHOLE	SCL			23-Jul-94	51	2.5		0		
GOPHERHOLE	SCL			23-Jul-94	79	7.5		0		
GOPHERHOLE	SCL			23-Jul-94	73	7		0		
GOPHERHOLE	SCL			23-Jul-94	70	7		0		
GOPHERHOLE	SCL			23-Jul-94	26			0		
GOPHERHOLE	SCL			23-Jul-94	62	3.5		0		
GOPHERHOLE	SCL			23-Jul-94	71	5		0		
GOPHERHOLE	SCL			23-Jul-94	84	9.5		0		
GOPHERHOLE	SCL			23-Jul-94	74	6.5		0		
GOPHERHOLE	SCL			23-Jul-94	86	11		0		
GOPHERHOLE	SCL			23-Jul-94	56	3		0		
GOPHERHOLE	SCL			23-Jul-94	69	7		0		
GOPHERHOLE	SCL			23-Jul-94	101	14		0		
GOPHERHOLE	SCL			23-Jul-94	38	1		0		
GOPHERHOLE	SCL			23-Jul-94	84	9.5		0		
GOPHERHOLE	SCL			23-Jul-94	52	2		0		
GOPHERHOLE	SCL			23-Jul-94	56	4		0		
GOPHERHOLE	SCL			23-Jul-94	56	3		0		
GOPHERHOLE	SCL			23-Jul-94	50	2		0		
GOPHERHOLE	SCL			23-Jul-94	38	1.5		0		
GOPHERHOLE	SCL			23-Jul-94	47	2.5		0		
GOPHERHOLE	SCL			23-Jul-94	43	2.5		0		
GOPHERHOLE	SCL			23-Jul-94	59	4.5		0		
T1	DACE			29-Aug-94	53	1.5		0		
T1	DACE			29-Aug-94	55	1.9		0		
T1	DACE			29-Aug-94	32	0.4		0		
T1	DACE			29-Aug-94	50	1.3		0		
T1	DACE			29-Aug-94	58	2		0		
T1	DACE			29-Aug-94	50	1.2		0		
T1	DACE			29-Aug-94	45	0.9		0		
T1	DACE			29-Aug-94	47	0.9		0		
T1	BT			29-Aug-94	49	1.2		0		
T1	BT			29-Aug-94	171	48.1		0		
T1	BT			29-Aug-94	109	12		0		
T1	BT	BL	15	14-Jul-94	623	2600		0		
T1	BT	OR	5131	02-Aug-94	376	516		0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag#[4]
TI	BT	OR	5132	02-Aug-94	507	1236		0		
TI	BT	OR	5133	02-Aug-94	516	1356		0		
TI	BT	OR	5140	02-Aug-94	255	173		0		
TI	GLY			29-Aug-94	85	6.7		0		
TI	GLY			29-Aug-94	70	3.6		0		
TI	GLY			29-Aug-94	67	2.6		0		
TI	GLY			29-Aug-94	71	3.1		0		
TI	GLY			29-Aug-94	82	5.5		0		
TI	GLY			29-Aug-94	69	3.1		0		
TI	GLY	BL	19	14-Jul-94	323	416	5+	0		
TI	GLY	BL	19	02-Aug-94	324	421	5+	1	BL	19
TI	GLY	BL	20	14-Jul-94	284	271	4+	0		
TI	GLY	BL	21	14-Jul-94	293	266	4+	0		
TI	GLY	BL	22	14-Jul-94	224	146	3+	0		
TI	GLY	BL	23	14-Jul-94	224	156	2+	0		
TI	GLY	BL	29	14-Jul-94	326	416	5+	0		
TI	GLY	BL	30	14-Jul-94	317	386	5+	0		
TI	GLY	BL	38	14-Jul-94	379	606	7+	1		
TI	GLY	BL	39	14-Jul-94	319	381	5+	0		
TI	GLY	BL	40	14-Jul-94	304	356	5+	0		
TI	GLY	BL	41	14-Jul-94	227	156	3+	0		
TI	GLY	OR	5126	02-Aug-94	369	546	6+	1	YW	16
TI	GLY	OR	5127	02-Aug-94	280	271	4+	0		
TI	GLY	OR	5128	02-Aug-94	315	406	5+	0		
TI	RBT			02-Aug-94	166	74	2+	0		
TI	RBT			02-Aug-94	257	226	Reg	0		
TI	RBT			02-Aug-94	181	93	2+	0		
TI	RBT			29-Aug-94	41	0.9		0		
TI	RBT			29-Aug-94	55	1.5	0+	0		
TI	RBT			29-Aug-94	33	0.2		0		
TI	RBT			29-Aug-94	39	0.6	n/s	0		
TI	RBT			29-Aug-94	107	14	1+	0		
TI	RBT			29-Aug-94	60	2.4	0+	0		
TI	RBT			29-Aug-94	118	8.5	1+	0		
TI	RBT			29-Aug-94	46	0.8		0		
TI	RBT			29-Aug-94	60	2.1		0		
TI	RBT			29-Aug-94	129	21.9	1+	0		
TI	RBT			29-Aug-94	46	0.8		0		
TI	RBT			29-Aug-94	56	1.7	n/s	0		
TI	RBT			29-Aug-94	56	2.1		0		
TI	RBT			29-Aug-94	107	13.7	1+	0		
TI	RBT			29-Aug-94	46	1.3		0		
TI	RBT			29-Aug-94	52	1.2		0		
TI	RBT			29-Aug-94	52	1.5	0+	0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag#[4]
TI	RBT			29-Aug-94	48	0.9		0		
TI	RBT			29-Aug-94	48	1.1		0		
TI	RBT			29-Aug-94	121	8.8	1+	0		
TI	RBT			29-Aug-94	94	9.4	1+	0		
TI	RBT			29-Aug-94	129	24.2		0		
TI	RBT			29-Aug-94	52	1.2	0+	0		
TI	RBT			29-Aug-94	55	1.4		0		
TI	RBT			29-Aug-94	90	9.1	1+	0		
TI	RBT			29-Aug-94	119	18.4	1+	0		
TI	RBT			29-Aug-94	40	0.7		0		
TI	RBT			29-Aug-94	77	5.5	0+	0		
TI	RBT			29-Aug-94	57	1.8		0		
TI	RBT			29-Aug-94	68	3.4	0+	0		
TI	RBT			29-Aug-94	90	8.9	1+	0		
TI	RBT			29-Aug-94	44	0.9		0		
TI	RBT			29-Aug-94	44	0.9		0		
TI	RBT			29-Aug-94	54	1.6		0		
TI	RBT			29-Aug-94	45	1.3		0		
TI	RBT			29-Aug-94	63	2.9	0+	0		
TI	RBT			29-Aug-94	51	1.3	0+	0		
TI	RBT	BL	16	14-Jul-94	296	296	5+	0		
TI	RBT	BL	17	14-Jul-94	208	121	4+	0		
TI	RBT	BL	18	14-Jul-94	200	111	3+	0		
TI	RBT	BL	*24*	14-Jul-94	213	146	3+	0		
TI	RBT	BL	*25*	14-Jul-94	237	171	3+	0		
TI	RBT	BL	*26*	14-Jul-94	214	131	3+	0		
TI	RBT	BL	*27*	14-Jul-94	285	316	4+	0		
TI	RBT	BL	*28*	14-Jul-94	257	216	3S	0		
TI	RBT	BL	31	14-Jul-94	200	111	3+	0		
TI	RBT	BL	32	14-Jul-94	322	401	5S	1	YW	27
TI	RBT	BL	33	14-Jul-94	247	191	3+	0		
TI	RBT	BL	34	14-Jul-94	311	301	4+	0		
TI	RBT	BL	35	14-Jul-94	258	211	3+	0		
TI	RBT	BL	36	14-Jul-94	206	126	3+	0		
TI	RBT	BL	37	14-Jul-94	220	146	3+	0		
TI	RBT	BL	42	14-Jul-94	224	151	3+	0		
TI	RBT	BL	43	14-Jul-94	295	271	4+	0		
TI	RBT	OR	5129	02-Aug-94	341	411	6+	0		
TI	RBT	OR	5130	02-Aug-94	301	321	5+	0		
TI	RBT	OR	5134	02-Aug-94	320	361	6+	0		
TI	RBT	OR	5135	02-Aug-94	253	206	3+	0		
TI	RBT	OR	5136	02-Aug-94	227	170	3+	0		
TI	RBT	OR	5137	02-Aug-94	242	157	5+	0		
TI	RBT	OR	5138	02-Aug-94	242	174	3+	0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag#[4]
T1	RBT	OR	5139	02-Aug-94	238	170	3+	0		
T1	RBT	OR	5141	02-Aug-94	241	176	3+	0		
T1	RBT	OR	5142	02-Aug-94	211	128	3+	0		
T1	RBT	OR	5143	02-Aug-94	272	241		0		
T2	DACE			28-Aug-94	53			0		
T2	DACE			28-Aug-94	56			0		
T2	DACE			28-Aug-94	25			0		
T2	DACE			28-Aug-94	54			0		
T2	DACE			28-Aug-94	58	2.1		0		
T2	BT			01-Aug-94	180	76		0		
T2	BT			28-Aug-94	43	0.8		0		
T2	BT			28-Aug-94	46	1.4		0		
T2	BT			28-Aug-94	49	1		0		
T2	BT			28-Aug-94	49	1.4		0		
T2	BT			28-Aug-94	47	1.2		0		
T2	BT			28-Aug-94	50	1.8		0		
T2	BT			28-Aug-94	43	0.9		0		
T2	BT			28-Aug-94	39	0.6		0		
T2	BT			28-Aug-94	39	0.6		0		
T2	BT			28-Aug-94	45	1		0		
T2	BT			28-Aug-94	41	0.8		0		
T2	BT			28-Aug-94	50	1.6		0		
T2	BT			28-Aug-94	39	0.8		0		
T2	BT			28-Aug-94	47	1.3		0		
T2	BT			28-Aug-94	52	1.7		0		
T2	BT			28-Aug-94	40	0.8		0		
T2	BT			28-Aug-94	41	0.8		0		
T2	BT			28-Aug-94	42	0.9		0		
T2	BT			28-Aug-94	39	0.6		0		
T2	BT			28-Aug-94	146	33		0		
T2	BT			28-Aug-94	48	1.1		0		
T2	BT			28-Aug-94	49	1.3		0		
T2	BT			28-Aug-94	45	1.1		0		
T2	BT			28-Aug-94	48	1.1		0		
T2	BT			28-Aug-94	42	0.7		0		
T2	BT			28-Aug-94	49	1.3		0		
T2	BT			28-Aug-94	38	0.6		0		
T2	BT			28-Aug-94	52	1.7		0		
T2	BT			28-Aug-94	48	1.2		0		
T2	BT			28-Aug-94	41	0.7		0		
T2	BT			28-Aug-94	47	1.3		0		
T2	BT			28-Aug-94	56	2.7		0		
T2	BT			28-Aug-94	48			0		
T2	BT			28-Aug-94	53			0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weigh. (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag #[4]
T2	BT			28-Aug-94	53			0		
T2	BT			28-Aug-94	161	41		0		
T2	BT			28-Aug-94	46			0		
T2	BT			28-Aug-94	44	0.8		0		
T2	BT			28-Aug-94	50	1.6		0		
T2	BT			28-Aug-94	48	1.5		0		
T2	BT			28-Aug-94	39	0.6		0		
T2	BT			28-Aug-94	45	1.2		0		
T2	BT			28-Aug-94	49	1.4		0		
T2	BT			28-Aug-94	45	1		0		
T2	BT			28-Aug-94	45	1.1		0		
T2	BT			28-Aug-94	47	1.6		0		
T2	BT			28-Aug-94	50	1.6		0		
T2	BT			28-Aug-94	48	1		0		
T2	BT			28-Aug-94	50	1.5		0		
T2	BT			28-Aug-94	44	0.9		0		
T2	BT			28-Aug-94	47	1.4		0		
T2	BT			28-Aug-94	47	1.4		0		
T2	BT			28-Aug-94	43	0.8		0		
T2	BT			28-Aug-94	46	1.1		0		
T2	BT			28-Aug-94	45	1		0		
T2	BT			28-Aug-94	46	1.3		0		
T2	BT			28-Aug-94	48	1.4		0		
T2	BT			28-Aug-94	35	0.4		0		
T2	BT			28-Aug-94	50	1.5		0		
T2	BT			28-Aug-94	43	1.1		0		
T2	BT			28-Aug-94	47	1.6		0		
T2	BT	BL	4	12-Jul-94	273	201		0		
T2	BT	BL	13	12-Jul-94	239	146		0		
T2	BT	RD	6081	12-Jul-94	660	2025		1	RD	6081
T2	BT	RD	6231	01-Aug-94	257	171		0		
T2	BT	RD	6244	01-Aug-94	520	1116		0		
T2	BT	RD	6253	01-Aug-94	309	296		0		
T2	GLY			01-Aug-94	183	90	2+	0		
T2	GLY			28-Aug-94	70	7	0+	0		
T2	GLY			28-Aug-94	82	10.5	0+	0		
T2	GLY			28-Aug-94	62	4.5	0+	0		
T2	GLY			28-Aug-94	69	3.1	0+	0		
T2	GLY			28-Aug-94	80	10	0+	0		
T2	GLY	BL	2	12-Jul-94	222	136	3+	0		
T2	GLY	BL	5	12-Jul-94	224	146	3+	0		
T2	GLY	RD	6232	01-Aug-94	331	431	5+	0		
T2	GLY	RD	6237	01-Aug-94	259	216	3+	0		
T2	GLY	RD	6254	01-Aug-94	199	108	0+	0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag #[4]
T2	GLY	WH	1	12-Jul-94	294	306	5+	1	WH	1
T2	MWF			28-Aug-94	72	3.7	n/s	0		
T2	MWF			28-Aug-94	64	2.2	n/s	0		
T2	MWF			28-Aug-94	76	4.4	n/s	0		
T2	RBT			12-Jul-94	155	61	2+	0		
T2	RBT			01-Aug-94	175	87	2+	0		
T2	RBT			01-Aug-94	126	42	1+	0		
T2	RBT			01-Aug-94	164	73	2+	0		
T2	RBT			01-Aug-94	174	79	2+	0		
T2	RBT			01-Aug-94	197	108	3+	0		
T2	RBT			01-Aug-94	163	73	2+	0		
T2	RBT			01-Aug-94	211	108	3+	1	LC	
T2	RBT			01-Aug-94	150	57	2+	0		
T2	RBT			01-Aug-94	228	138	4+	0		
T2	RBT			01-Aug-94	221	129	3+	0		
T2	RBT			01-Aug-94	192	98	3+	0		
T2	RBT			01-Aug-94	152	55	2+	0		
T2	RBT			01-Aug-94	164	70	2+	0		
T2	RBT			01-Aug-94	175	74	3+	0		
T2	RBT			28-Aug-94	38			0		
T2	RBT			28-Aug-94	38	0.4	0+	0		
T2	RBT			28-Aug-94	39	0.6	0+	0		
T2	RBT			28-Aug-94	39	0.6	0+	0		
T2	RBT			28-Aug-94	43	1	0+	0		
T2	RBT			28-Aug-94	51	1.5	0+	0		
T2	RBT			28-Aug-94	34	0.2	0+	0		
T2	RBT			28-Aug-94	37	0.3	0+	0		
T2	RBT			28-Aug-94	38	0.4	0+	0		
T2	RBT			28-Aug-94	38	0.4	0+	0		
T2	RBT			28-Aug-94	40	0.4	0+	0		
T2	RBT			28-Aug-94	52	1.5	0+	0		
T2	RBT			28-Aug-94	37	0.4	0+	0		
T2	RBT			28-Aug-94	48			0		
T2	RBT			28-Aug-94	48	1	0+	0		
T2	RBT			28-Aug-94	110	18.5	1+	0		
T2	RBT			28-Aug-94	42	0.8	0+	0		
T2	RBT			28-Aug-94	37	0.7	0+	0		
T2	RBT			28-Aug-94	47	0.8	0+	0		
T2	RBT			28-Aug-94	50			0		
T2	RBT			28-Aug-94	56			0		
T2	RBT			28-Aug-94	108	19	1+	0		
T2	RBT			28-Aug-94	45	0.9	0+	0		
T2	RBT			28-Aug-94	55			0		
T2	RBT			28-Aug-94	51	1.3	0+	0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag #[4]
T2	RBT			28-Aug-94	48	1.4	0+	0		
T2	RBT			28-Aug-94	54	1.9	0+	0		
T2	RBT			28-Aug-94	49	1.2	0+	0		
T2	RBT			28-Aug-94	50			0		
T2	RBT			28-Aug-94	37	0.4	0+	0		
T2	RBT			28-Aug-94	49			0		
T2	RBT			28-Aug-94	56			0		
T2	RBT			28-Aug-94	39			0		
T2	RBT			28-Aug-94	38	0.5	0+	0		
T2	RBT			28-Aug-94	42	0.7	0+	0		
T2	RBT			28-Aug-94	39	0.4	0+	0		
T2	RBT			28-Aug-94	36	0.4	0+	0		
T2	RBT			28-Aug-94	40			0		
T2	RBT			28-Aug-94	42	1	0+	0		
T2	RBT			28-Aug-94	43	0.9	0+	0		
T2	RBT			28-Aug-94	53			0		
T2	RBT			28-Aug-94	52			0		
T2	RBT			28-Aug-94	53	1.6	0+	0		
T2	RBT			28-Aug-94	119	23	1+	0		
T2	RBT			28-Aug-94	121	29.5	1+	0		
T2	RBT			28-Aug-94	53			0		
T2	RBT			28-Aug-94	48			0		
T2	RBT			28-Aug-94	55			0		
T2	RBT			28-Aug-94	37	0.4	0+	0		
T2	RBT			28-Aug-94	107	12.7	1+	0		
T2	RBT			28-Aug-94	49	1.2	0+	0		
T2	RBT			28-Aug-94	42	0.7	0+	0		
T2	RBT			28-Aug-94	47	1.4	0+	0		
T2	RBT			28-Aug-94	43	0.8	0+	0		
T2	RBT			28-Aug-94	36	0.5	0+	0		
T2	RBT			28-Aug-94	41	0.5	0+	0		
T2	RBT			28-Aug-94	37	0.5	0+	0		
T2	RBT			28-Aug-94	50	1.6	0+	0		
T2	RBT			28-Aug-94	41	0.7	0+	0		
T2	RBT			28-Aug-94	36	0.4	0+	0		
T2	RBT			28-Aug-94	48	1.4	0+	0		
T2	RBT			28-Aug-94	49	1.5	0+	0		
T2	RBT			28-Aug-94	37	0.5	0+	0		
T2	RBT			28-Aug-94	48	1.1	0+	0		
T2	RBT	BL	3	12-Jul-94	216	131	3+	0		
T2	RBT	BL	6	12-Jul-94	189	96	3+	0		
T2	RBT	BL	7	12-Jul-94	245	186	4+	0		
T2	RBT	BL	8	12-Jul-94	210	121	3+	0		
T2	RBT	BL	9	12-Jul-94	245	191	4+	0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag #[4]
T2	RBT	BL	10	12-Jul-94	264	226	4+	0		
T2	RBT	BL	11	12-Jul-94	246	183	4+	0		
T2	RBT	BL	12	12-Jul-94	205	116	3+	0		
T2	RBT	BL	14	12-Jul-94	247	176	4+	0		
T2	RBT	RD	6226	01-Aug-94	313	311	5+	0		
T2	RBT	RD	6227	01-Aug-94	240	181	3+	0		
T2	RBT	RD	6228	01-Aug-94	293	266	4+	0		
T2	RBT	RD	6229	01-Aug-94	248	191	3+	0		
T2	RBT	RD	6230	01-Aug-94	214	123	3+	0		
T2	RBT	RD	6233	01-Aug-94	336	366	4S	0		
T2	RBT	RD	6234	01-Aug-94	204	116	3+	0		
T2	RBT	RD	6235	01-Aug-94	219	136	3+	0		
T2	RBT	RD	6236	01-Aug-94	224	144	3+	0		
T2	RBT	RD	6238	01-Aug-94	287	271	4+	0		
T2	RBT	RD	6239	01-Aug-94	255	191	3+	0		
T2	RBT	RD	6240	01-Aug-94	288	266	5+	0		
T2	RBT	RD	6241	01-Aug-94	214	142	3+	0		
T2	RBT	RD	6242	01-Aug-94	238	164	4+	0		
T2	RBT	RD	6243	01-Aug-94	281	256	3S	0		
T2	RBT	RD	6245	01-Aug-94	232	64	3+	0		
T2	RBT	RD	6246	01-Aug-94	221	150	3+	0		
T2	RBT	RD	6247	01-Aug-94	271	236	4+	0		
T2	RBT	RD	6248	01-Aug-94	207	127	3S	0		
T2	RBT	RD	6249	01-Aug-94	207	126	3+	0		
T2	RBT	RD	6250	01-Aug-94	313	366	4S	0		
T2	RBT	RD	6251	01-Aug-94	203	no	3+	0		
T2	RBT	RD	6252	01-Aug-94	299	346	5+	0		
T2	RBT	RD	6255	01-Aug-94	249	178	2S	0		
T2	RBT	RD	6256	01-Aug-94	328	351	4S	0		
T2	RBT	RD	6257	01-Aug-94	314	416	4S	0		
T2	RBT	RD	6258	01-Aug-94	233	186	3+	0		
T2	RBT	RD	6259	01-Aug-94	219	128	3+	0		
T2	RBT	WH	42	01-Aug-94	265	241	4+	1	WH	42
T2	SCL			28-Aug-94	65	4		0		
T2	SCL			28-Aug-94	80	7		0		
T2	SCL			28-Aug-94	74	6		0		
T2	SCL			28-Aug-94	75	7.5		0		
T2	SCL			28-Aug-94	70	9		0		
T2	SCL			28-Aug-94	70	8		0		

Location	Species[1]	Floy Tag Color[2]	Floy Tag #	Date	Len. (mm)	Weight (grams)	Age	Tag[3]	Old Floy Color[4]	Old Floy Tag #[4]
T2	SCL			28-Aug-94	72	9.5		0		
T2	SCL			28-Aug-94	60	7		0		
T2	SCL			28-Aug-94	60	5		0		
T2	SCL			28-Aug-94	68	9		0		

1. Species: BUR - burbot, DACE - longnose dace, BT - bull trout, RBT - rainbow trout, GLY - Arctic grayling, MWF - mountain whitefish, SUCK - sucker (Catastomus spp.), SCL - sculpin (Cottus spp.).
2. Floy Tag Colour: Colour of floy tag for salmonids >200 mm and type of fin clip for salmonids < 200 mm, GR - green, BL - blue, YW - yellow, OR - orange, PK - pink, RD - red, WH - white, LC - lower caudal fin clip, UC - upper caudal fin clip, DC double (lower and upper) caudal fin clip.
3. Tag: Indicates whether a fish was previously tagged, 0 - first time capture, 1 - recapture.
4. Old Floy Colour and Tag Number: Indicates the tag colour and number for a recaptured fish. In cases were the old number differs from the current number, the old floy tag was removed due to its condition or placement.